JOURNAL OF ECONOMIC ENTOMOLOGY
Official Organ American Association of Economic Entomologists

Vol. 34 February, 1941 No. 1

Racial Segregation in Insect Populations and Its Significance in Applied Entomology[1]

Presidential Address, Annual Meeting of the American Association of Economic Entomologists, Philadelphia, Pennsylvania, December 27, 1940

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INTRODUCTION.—The possibility that an insect species might materially change its habits within the lifetime of an individual entomologist has been regarded with a great deal of skepticism by many investigators. Physiological variation within many species is readily admitted but it has been maintained that this variation is usually individual and nongenetic, like environmentally induced variation in structure and color. The habits of a species are usually supposed to be as fixed as its specific morphological characters and are not expected to change in less than quasigeological periods of time.

In recent years, however, workers in the field of economic entomology have repeatedly encountered phenomena which tend to throw considerable doubt on this belief in the fixity of habit within a species. Changes have occurred in the habits of several species of insect pests, which *appear* to be correlated with environmental changes brought about by agriculturists in the pursuit of their calling. If this apparent relation proves to be a fact, it is one of far-reaching importance.

Will continued, intense pest control operations result in the development of insect races which become harder and harder to control? Can a species which has for many years been of no economic importance, relative to certain kinds of cultivated plants, develop, in time, races which become major pests of those plants? Can a species introduced into a new habitat having climatic characteristics differing adversely from those of its native home, gradually develop a race which thrives under those formerly adverse conditions? If these questions are answered in the affirmative, that fact is of great significance to the profession of economic entomology.

The development of insect races is such an important matter that it has seemed worth while to study it critically and to present the results to the membership of the American Association of Economic Entomologists. This is done, not with the idea of offering new evidence or even new interpretations of old evidence, but rather in the hope that you will find the subject of such moment that you will interest yourselves in it more actively.

EVIDENCE FOR RACIAL SEGREGATION.—That races of insects exist within species, of course no one will deny.[3] Taxonomists have always been more or less occupied with morphological races, particularly those correlated with geographic distribution. We are not concerned here, however, with races of that kind. The races which we are considering are not, so far as we know, morphological, in the usual sense of the term. They are not necessarily visibly distinguishable from each other. They differ in habit, in physiological or psychological characteristics rather than in structure or color. They also differ in that, in general, they seem to have developed within the memory and more or less under the direct observation of those entomologists reporting them; whereas the geographical and other morphological or color races have supposedly been in existence for geological periods of time.

Although Walsh (1864, 1865) proposed the hypothesis that insect populations

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[3] For an excellent review of the whole question of insect races, see Thorpe (1930, p. 177–212).

consisted of races which were destined later to become fixed as species, Melander (1914) was the first to call attention to evidence that an insect of economic importance was becoming increasingly harder to kill. His records showed fairly conclusively that in certain localities the San José scale, *Aspidiotus perniciosus* Comst., had become more difficult to control with lime-sulfur after regular treatment over an extended period. This work attracted a good deal of attention, but the suggestion that the species was becoming resistant to insecticides met with considerable skepticism.

In 1916, however, Quayle (1916) called attention to the apparent development of a strain or race of red scale, *Aonidiella aurantii* (Mask.), on citrus at Corona, California, that was far more difficult to control with cyanide fumigation than the general population of red scale in most other localities. This difference in control was strikingly evident in the field, not only to entomological observers, but also to professional fumigators engaged in large-scale field work.

That this development of a race of scale which was harder to control than the general scale population was not a unique occurrence but had back of it some fundamental biological principle, seems to have been indicated by the appearance, later, of races of two other species infesting citrus, namely, the black scale, *Saissetia oleae* (Bern.), and the citricola scale, *Coccus pseudomagnoliarum* (Kuw.). It is true that neither of these species has received such intensive study from the standpoint of cyanide resistance as has the red scale; but the observations and research of Quayle, Woglum, Lindgren, and others, as well as the experiences of commercial fumigators, leave no doubt that the black scale, particularly in the Charter Oak area of California, and the citricola scale in several localities have definitely developed races which are much harder to kill than the "ordinary" populations of this species.

Thus it is claimed that four species of scale insects have, within the lifetime of one entomologist, evolved races which are harder to kill with certain insecticidal treatment than the ordinary populations of those species or than any of the populations of, say twenty-five years ago.

Nor does this phenomenon seem to be limited to the Coccidae or to the effect of contact sprays and gases. In 1928, in a very interesting paper, Hough (1928), of Virginia, called attention to the difference in the ability of larvae of the codling moth, *Carpocapsa pomonella* L., from the widely separated apple-growing regions of Virginia and Colorado, to enter apples sprayed with lead arsenate. Hough was led to suspect racial differences because of the great discrepancy in the number of sprays required in the control programs of the two localities, as indicated by the studies of Siegler & Plank (1921).

And not only have races of insects developed which are increasingly harder to control by use of insecticides; the phenomenon is broader than that. There are recorded in the literature many examples of insect races which are restricted to certain hosts. The "host-selection principle" was enunciated by Hopkins (Craighead 1921) as a result of the observation that a species of *Dendroctonus*, which attacks various pines, tends to develop races or strains in which the ovipositing adult shows a very marked preference for the host species in which it, as a larva, developed.

One of the most striking and important examples of what appears to be a host-determined race is the so-called "walnut codling moth." This insect, *Carpocapsa pomonella*, has become a major pest of the Persian walnut in California in recent years (Quayle 1926, Boyce 1935). That it is a distinct genetic race has not yet been proved, but its behavior is difficult to explain on any other basis.

Extensive investigation by Thorpe (1929, 1931), in England, on the small ermine moth, *Hyponomeuta padella* L., showed conclusively that the populations of this species on apple constituted a race distinct from that of the populations on hawthorn. It would be possible to cite many other examples, some supported by what seems to be conclusive proof and others of doubtful validity; but we are concerned, rather, with the general principles involved.

There are also, in the literature, many references to races of entomophagous insects. Certain egg parasites of the genus *Trichogramma* are supposed by many workers to exhibit distinct races based on host and habitat preferences; other workers regard these as distinct species in

which little or no morphological differentiation has yet been detected (Peterson 1930).

There are not many definite instances of the natural development of insect races which are especially adapted to certain conditions of climate, such as temperature. However, since laboratory races of a species of *Drosophila* have been shown to be strikingly different in their responses to temperatures (Dobzhansky 1937; p. 20, 154), it would not be surprising to find that such races do occur commonly. In this case, developmental zeros, thermal death points, thermal constants, and so forth, would not be *specific* constants—a matter of some interest to ecologists.

It will appear from these examples, which could be increased many fold, that populations of insects do become segregated into physiological races, the characteristics of which may have a very important bearing on their economic significance. It would be of no value merely to point this out. The important question is whether the habits and physiological characteristics of economic species are capable of changing *within relatively short periods of time and as a result of changes in their environment brought about by man himself*—changes effected by the application of insecticides or changes induced in the flora or fauna of the area inhabited. An attempt to answer this question involves, however, some consideration of certain broad principles of genetics in relation to organic evolution.

THE GENETIC BASIS FOR RACIAL SEGREGATION WITHIN POPULATIONS.—This is not the place, even though I had the knowledge, to examine this question in all its interesting genetical and evolutionary aspects. But we may, I think, profitably take the time to consider the bearing which some of the more generally accepted beliefs in this connection have on the question of the origin of these physiological races, and may then draw our own conclusions as to their adequacy to explain it.

It is gratifying to note that the interests of geneticists and economic entomologists seem to be converging on this question at this time, greatly to the advantage of both. The geneticists, who in very recent years have tended to leave the laboratory and go directly into the field for their data, have approached the question from the evolutionary angle. And Dobzhansky, who is both entomologist and geneticist, has recently given a most excellent review of the whole question in his book, *Genetics and the Origin of Species* (Dobzhansky 1937).

While organic evolution is still one of the most fertile fields for controversy, I belong to that vast majority of biologists who believe that the Neo-Darwinian hypothesis involving the three steps, genetic variation, natural selection, and isolation, is the best theory yet advanced to explain the origin of species. The origin of insect races is best explained in the same manner. The nature of variation is, therefore, basic to the whole question.

Variations may be grouped into two great classes. The first class is comprised of those individual variations which are environmentally induced and are not, therefore, hereditary in the usual sense. This class is well illustrated by two examples, namely, by the direct effect of the host-plant species on the form of *Lecanium corni* (Bouché), as described by Ebeling (1938); and by the direct effect of the habitat on the form of the human louse, *Pediculus humanus* L., as brought out by Nuttall (1919). Such variations should not be called races. The second class is made up of those variations which are caused by gene mutations and are definitely hereditary. Plainly, only the latter class of variations, that is, those caused by gene mutations rather than by the direct effect of the environment on the individual, need concern us in this discussion, since only they can give rise to races.

Now most modern geneticists believe that these autogenous variations are entirely random and occur without any reference to their potential usefulness or uselessness, favorableness or unfavorableness to the organism. Although the environment may modify the intensity of rates of mutation, there is no evidence that it affects its qualities. Thus Dobzhansky (1937, p. 127), in pointing out the importance of these mutations, states that the species must possess

> " . . . at all times a store of concealed, potential variability. This store will presumably contain variants which under no conditions will be useful, other variants which might be useful under a set of circumstances which may never be realized in practice, and still other variants which were neutral or harmful at the time when they were produced but which will prove useful later on."

These conclusions are, of course, largely

the result of the intensive study of mutation in *Drosophila*, but there is much corroborative evidence from other animals and from plants.

The mutations studied have been mainly those producing easily visible morphological or color variants, although considerable attention has been given to such physiological mutations as lethals and to some other non-visible mutations. These non-visible mutations are just as common and follow the same laws as the visible ones. The relatively little study given them by geneticists is simply attributable to the much greater labor necessary, as a rule, in identifying them and in measuring their frequency. From the standpoint of applied science, they are far more important, since it is largely they and not the morphological and color variations that determine what an organism *does*. We may conclude, then, that within the populations of a species of insect, mutants are constantly appearing . . . not only those which are distinguished by morphological and color characteristics, but also those which alter the physiological qualities, including psychology and habit.

The fate of these individual genetic variants is determined largely by environmental selection. Variants which have superior survival power, according to this theory, will replace those not having it and will tend to pass this quality on to their progeny. What effect does this have on the composition of the population? If these variants tend to replace the "normal" members of the population because of greater power of survival under the changed environmental conditions, then the characteristics of the population must shift in such a way that, in time, the population will be composed largely of those variants which are better adapted to exist under the conditions.

Such a shifting of the characteristics of a population results in the segregation of a race which differs from the original population, a race obviously better adapted to maintain itself than would have been possible had this change not taken place.

A shift of the characteristics of the population in the direction of greater fitness *must* occur if variants are present which are superior to the general population in their ability to persist and to leave progeny in the presence of the changed conditions; if the superiority of the variants is hereditary; and if the frequency of interbreeding with other races is retarded.

While it is possibly true that populations of some species consist of a single homozygous race, it seems certain that in most species the populations contain many concealed "potential" races the race which is *actually dominant* having become so as a result of selection, it being the "fittest" under those particular environmental conditions.

According to Dobzhansky (1937, p. 48), "The individual variability, in so far as it is hereditary, may be likened to a store of building materials; the process of race formation consists in arranging the materials in definite patterns." The nature of the pattern depends, of course, upon the environment, and important modifications in the latter may be followed by changes in the pattern.

The total possible number of mutations of a species is probably constant and is probably a specific characteristic which changes only during those geologic intervals of time when the species itself is undergoing evolutionary change. The absence, in a particular environment, of any given race which the species is capable of producing is then, in general, due not to the absence of the mutation potentially capable of giving rise to that race, but rather to the lack of proper environmental and other conditions which will make that mutation dominant.

If, therefore, by some cultural practice, a portion of the environment of an insect species is materially changed, and if there exists an occasional mutant which is superior to the general population in its ability to survive under the changed conditions, we have the *potentiality* of the development of a race differing from that previously representing the species. Whether a race will *actually* develop, and how long it may take, depends entirely upon certain quantitative relations. The degree of superiority of one mutant over another and the degree of interbreeding with the population in the unchanged part of the environment, which is, of course, influenced by the dissemination of the individuals, determine whether and how soon a different race will appear to replace the former one.

It will be seen from this that the segregation of insect races does not differ in principle from the development of a new

breed of domestic animal by a practical breeder. And while a new breed of domestic animal has, in numerous instances, been developed within a period of a very few years—fewer than those of a normal human lifetime—it seems evident that with insects even less time would be required in some cases, since the sequence of generations is so much more rapid.

So far as our knowledge goes, both of the art of breeding and of the science of genetics, there is nothing inconsistent with the idea that, under cultural practices, insect species can easily develop new races within the lifetime and under the direct observation of an individual entomologist. We are accustomed to think of the origin of a new species as a process requiring time on a geological scale, and that is probably true. But the part of the process which takes great time is not the segregation of the race which is destined to become the species, but, rather, the evolution of its inability to interbreed with the relatives from which it has been isolated. In regard to race formation, Dobzhansky (1937), p. 62, 63) writes as follows:

> " . . . mechanisms preventing the interbreeding of races may develop, splitting what used to be a single collective genotype into two or more separate ones. When such mechanisms have developed and the prevention of interbreeding is more or less complete, we are dealing with separate species."

It is this development of mechanisms to make interbreeding difficult or impossible that may require time on a geological scale. Races are maintained distinct solely because interbreeding is reduced by their separation in time or place. Species are maintained distinct because they *cannot* interbreed (normally) even though associated in both time and place.

We may now return to some of the examples of alleged race formation in insect populations to consider the present state of our knowledge concerning this problem.

RACES AND INSECTICIDES.—By compelling an insect species to live in a habitat where it is subjected to the action of lethal chemicals, we are producing a fundamental change in its environmental relations. Let us consider what effect this might have on the composition of populations of certain species, in the light of the genetic principles previously mentioned. A few examples will suffice.

The Citrus Coccids in California.—The claim that there has developed, in California, a race of red scale which is greatly resistant to cyanide fumigation, as compared to the "ordinary" population, has now received a considerable amount of study; and the evidence of such a development seems conclusive.

Quayle (1916) brought infested lemons from "resistant" and "nonresistant" areas into the laboratory, fumigated them side by side in the same fumatorium, and found a strikingly significant difference in the survival of insects from the two areas. These differences in survival were of the order of 1 per cent from the "nonresistant" areas as compared with 20 per cent from the "resistant" areas. It will readily be seen that such a difference in survival would determine success or failure in control, particularly with an insect such as the red scale, which has at least three generations to one treatment. Woglum (1925), working independently, corroborated these findings.

That this difference in resistance is not caused by immediate environmental influences, such as possible differences in the host, soil, or climate, has been conclusively demonstrated by Quayle (1938) and by Lindgren (1938), who have now propagated at least thirty-five generations of pure cultures of both races under identical, controlled conditions in the insectary and on similar fruits. The difference in susceptibility to cyanide still persists as strikingly as when the scale were first brought in from the field. Furthermore, intensive research has shown that this quality of resistance is inherited in accord with Mendel's law, and that it is a sex-linked character (Dickson 1941).

The fact of the existence of this resistant race is therefore no longer open to doubt. The questions which now arise for discussion are: (1) Where did the mutations originate? (2) Why has the race not become prevalent in all fumigated areas? and (3) What is the nature of the mechanism which makes it resistant to fumigation? In the absence of definite information bearing on these questions, perhaps we may indulge in a little speculation.

Since, in general, all possible mutations in a species are likely to occur in any large population, regardless of the environment, it seems unnecessary to debate the point as to whether the resistant race had a different exotic origin from the nonresistant

race. It is more probable that these resistant mutants appear within any densely inhabited area from time to time and that the ability to produce this mutant is a part of the scale's normal "store of concealed, potential variability."

But the population shift from a nonresistant to a resistant race does not always occur because of reasons having to do with selection, relative rates of increase, and interbreeding. The question often arises as to why the resistant race of red scale has not appeared in the San Gabriel Valley, where fumigation has been practiced longer than in any other part of California, while it has become dominant in other areas, such as Corona and Glendora, in which the practice of fumigation is more recent. We must assume, I think, that in the absence of fumigation the nonresistant race is superior to the resistant. Otherwise, the nonresistant race would not have been the dominant one in the absence of fumigation. If this is true, then the dominance of one race or the other would depend upon the relative survival powers of the two races in the presence of fumigation, and the relative rates of population growth of the two between fumigations.

In the "resistant" areas, fumigation is necessarily an annual or even more frequent practice; in the "nonresistant" areas, it is resorted to, say once every two or three years. Under these conditions, given certain differentials in the rates of reproduction and survival of the two races, it is possible to show that frequent fumigation would keep the resistant race dominant. Less frequent fumigation, though it permitted the same relative percentages of survival of the two races in the generation fumigated, would enable the nonresistant race always to maintain its dominance. This would result from the ability of the nonresistant race to build up in numbers more rapidly during the longer intervals between fumigations. In other words, it is believed that the resistant mutants are present in the nonresistant area, but that their frequency is low for the reasons stated.

This is a simple hypothesis advanced to explain the differences in degree of resistance of the populations in different localities without resorting to the illogical assumption that the resistant mutations occurred with extreme rarity and perhaps only before the introduction of the red scale into California. There are strong indications of a higher rate of population growth in the nonresistant race in the insectary.[4] If it is shown that by frequent laboratory fumigations the "resistant" mutants can be obtained from populations from "nonresistant" areas, this hypothesis is sufficient to explain the presence or absence of the resistant race in a district.

The nature of the "resistance mechanism" is, up to the present time, entirely unknown. Quayle (1938) reports that the resistant race of red scale is also harder to kill with other gases, such as ethylene oxide and methyl bromide. He did not find it harder to kill with oil sprays. If the resistance is limited to gases, it would suggest that some respiratory mechanism is involved. A considerable amount of research is now being devoted to this question by the University of California, but much remains to be done before the phenomenon is thoroughly understood.

The Codling Moth.—The other outstanding example of race segregation resulting from application of insecticides is that of the codling moth on apples, to which I have already referred.

In order that the effect of environmental, host, and control-program variables might be eliminated, Hough (1928, 1929, 1934) brought stocks of codling moth from Colorado to his laboratory in Virginia for comparative study. The results of this work are so well known to economic entomologists that their detailed discussion here is superfluous.

The Colorado strain was found not only to be able to enter apples sprayed with arsenic much more successfully than the Virginia strain, but to show the same superiority when other sprays, including cryolite, barium fluosilicate, rotenone, nicotine, and cuprous cyanide, were applied. The "resistance," therefore, was not specific for arsenicals. Hough found also that the Colorado race had a significant superiority over the Virginia race in its ability to resist starvation and in its ability to survive fumigation with potassium cyanide in the well-incubated egg stage and in young larval stages.

All this evidence caused Hough to conclude that the superiority of the Colorado race consisted not merely in ability to survive greater dosages of insecticides or to

[4] Lindgren, D. L. Unpublished notes on file at the University of California Citrus Experiment Station.

enter sprayed apples more successfully, but in something of a more general nature, which he called "greater vigor."

If, however, the Colorado race is superior to others in its resistance to so many kinds of unfavorable environmental influences; and if, as Hough has shown, a similar race can be bred even from the Virginia populations by selection and is probably potentially present in all populations; it is difficult to understand why this superior race has not become dominant everywhere, regardless of the application of arsenicals for its control. It is possible that here, also, as suggested in the case of the red scale, the codling-moth race of which the Virginia population is typical, may have the greater capacity to build up in numbers; and in the absence of unusually severe environmental resistance, such as would exist in heavily sprayed orchards, it may be able to maintain its dominance in the population because of its higher rate of increase. Comprehensive data proving this superior rate of increase do not seem to be available although hinted at by Hough (1928); but there is a well-founded general principle of biology, referred to by Herbert Spencer as the antagonism between individuation and genesis, holding that there is an inverse relation between reproductive capacity and ability to withstand environmental resistance. It seems certain that the Colorado race must have some weakness as compared to the Virginia race; otherwise it should have become dominant everywhere.

At any rate, Hough's researches give good grounds for assuming that codling-moth populations in general have the potentiality of this resistant race and require only sufficiently severe control measures, acting as a selective factor, to give it dominance.

HOST-DETERMINED RACES.—Entomological literature contains many references to insect races which show a preference for certain food plants. The origin of most of these races, however, occurred before that time when entomological observations were first recorded; and in but few cases has the development of such a race actually been witnessed by entomologists.

The Walnut Codling Moth.—One of the most interesting of these host-determined races is the walnut codling moth previously mentioned. There seems little doubt that a distinct walnut-preferring race has developed; otherwise it is difficult to account for the fact that although walnuts, pome fruits, and the codling moth have existed together in California since 1873, and although the moth has been a severe pest on pome fruits for many decades, only since 1918 has it become a major pest of walnuts.

Quayle (1926) was unable to detect morphological or color differences in either the adults or larvae of the two supposed races, and his tests indicated that the adults had no host preferences when it came to oviposition. However, races might be morphologically identical and have similar ovipositional responses and still be definitely distinguishable by other characters. The necessity for synchronization of the insect's life cycle with the seasonal development of the different species of hosts, for example, might result in racial segregation.

Possibly the walnut does not become susceptible to successful attack until later in the spring than the apple. If genetic forms of the moth exist, which differ in their seasonal development in such a way that oviposition is delayed to coincide with walnut susceptibility, it is plain that the later ovipositing lines would leave relatively more progeny on walnuts. Thus, in time, a race would develop having a seasonal history highly adapted to the walnut. Such a condition would be brought about if there existed genetic variants having a longer winter diapause in the larva, or if the adults of the overwintering generation were longer-lived and thereby had a longer ovipositional period.

Goldschmidt (1934) found that one of the racial differences in the gypsy moth was the length of the winter diapause of the egg. Quayle (1926) noted that on the same date in the spring, 15 per cent of the overwintering larvae of the codling moth from apples had pupated, as against only 10 per cent from walnut. The last walnut larva pupated about 10 days later than the apple larvae. Flanders (1925) found that the adult moths from the overwintering generation on walnut lived considerably longer than those on apple. These differences were not large, and the data were not very extensive, but further studies are being made. If these tentative conclusions regarding length of larval diapause and adult life prove to be sound, they will

serve to explain the segregation of a walnut race, since even small advantages, if maintained, are eventually decisive factors.

Certain peculiar, *isolated* outbreaks of the codling moth on walnuts, such as that described by Foster (1910), are difficult to explain. This outbreak, which resulted in as high as 50 per cent infestation of walnuts, was largely limited to one season. The adult moths came from a near-by pear-packing shed, where the larvae had hibernated. Since the evidence indicates that neither moths nor larvae of the "normal" population distinguish between pome fruits and walnuts, any abnormal condition producing large numbers of moths from pome fruits in the immediate vicinity of susceptible walnuts could result in a heavy infestation. This infestation would not necessarily persist beyond that particular season, however, since the population would not consist of the true walnut race. It seems likely that for the segregation of the walnut race a certain degree of isolation of walnuts from infested apple orchards is necessary; otherwise there will be so much interbreeding that the races will not maintain their identity.

The walnut codling moth appears to be one of the relatively few cases where a race *recently* adapted to a new food plant has become of economic importance. The apple maggot, *Rhagoletis pomonella* (Walsh), seems to be another, although there may be some question as to whether it really is conspecific with the form on blueberry.

Wood-Boring Insects.—The situation with reference to host races in forest entomology, as exemplified by Hopkins' host-selection principle (Craighead 1921), is most interesting. There is nothing, however, to indicate that these host races have developed suddenly as a result of man's activities. Craighead's (1921) experimental work was directed toward determining the extent to which these races occurred, and he limited himself to presenting the facts without an extended attempt to explain *why* adults reared from larval populations which had developed in certain host woods selected that host species for oviposition in preference to others.

In Craighead's published data, I am unable to find evidence that these host races differ fundamentally in their origin from the other insect races previously discussed. The simplest explanation is that a population of a polyphagous species of cerambycid is mixed, containing perhaps several host-race genes in its germ plasm. The limiting of such a population to a single host species in confinement would gradually give dominance to any race especially adapted to that host, so that after a few generations the population would be predominantly of that race; just as a mixed population of resistant and nonresistant red scale will, in time, if continually subjected to fumigation, become predominantly of the resistant race.

Craighead frequently calls attention to the high mortality in the young stages of cerambycids in the early generations when the population is restricted to a single species of host differing from the one in which the parents originated. This is what would be expected if the foregoing explanation holds. Propagation from the survivors would eventually give the effect he mentions (Craighead 1921, p. 219); that is: "Continued breeding in a given host intensifies the preference for that host." It is not necessary, therefore, to resort to such explanations as "larval memory" or to a Lamarckian hypothesis, in which the host is supposed to influence the germ plasm directly in such a way that the following generations prefer that host species. This does not, of course, affect either the validity or the practical importance of the "host-selection principle."

Larson (1927), working with the cowpea weevil, *Callosobruchus maculatus* (F.), was unable to demonstrate the existence of the host-selection principle in that species. Thompson & Parker (1928) could find no definite evidence of it in the European corn borer, *Pyrausta nubilalis* (Hbn.) This phenomenon would not necessarily be general, however.

The Hessian Fly, Phytophaga destructor [Say].—Painter (1930) has shown that in Kansas there exist at least two races of hessian fly which differ materially in their ability to infest the same variety of wheat under identical environmental conditions. He found, however, that by breeding and selection he could change the characteristics of those races so that they would have approximately equal ability to infest the same variety of wheat. He states that "the hessian fly population of any one locality consists of a mixture of two or more strains, which differ in their ability to infest different varieties of wheat." These

strains or races are genetically distinct.

Dactylopius tomentosus (Lamarck).—The Australian entomologists who undertook the control of the prickly pear pest, *Opuntia* spp., by the introduction of phytophagous insects from the Western Hemisphere, have presented strong evidence that the mealybug species, *Dactylopius tomentosus*, is composed of several physiological races, each especially adapted to one or more species of *Opuntia*.

Entomophagous Parasites.—Host-determined races within the populations of entomophagous species of insects are also recorded in the literature. For example, Thompson & Parker (1927) refer to several such cases among the Tachinidae, which they encountered in their work on the European corn borer.

One especially interesting and puzzling example of racial segregation among entomophagous insects is found in the case of *Macrocentrus ancylivorus* Roh., a parasite of the oriental fruit moth. This species is believed to have occurred in parts of the United States on the strawberry leaf roller, *Ancylis comptana* (Froel.), before the introduction of the oriental fruit moth. It seems to have been demonstrated, however, that only the race which came originally from New Jersey can be relied on to give good control of the oriental fruit moth.

One must, however, always keep in mind that in an altogether too large proportion of cases, insufficient work has been done on these "races" to eliminate the possibility of their being, in reality, either true species which are extremely alike morphologically. Unfortunately, as Thorpe (1930) well points out, in many of these cases detailed mating experiments have not been made. For this reason, it is quite possible that many examples of supposed races will, on more critical study, turn out to be distinct species with little or no morphological differentiation in the adults. The crying need at the present time is for more intensive study of some of these supposed races, particularly through breeding experiments, to clarify these points.

PRACTICAL SIGNIFICANCE OF RACIAL SEGREGATION.—It is now necessary to consider the general significance of the phenomenon of physiological race segregation in applied entomology. Obviously, if the habits or other characteristics of a species can be materially changed by man's agricultural practices, it is important to take this into account and to modify our crop-protection programs so as to minimize or magnify its effects, as the case may require. In order to do this intelligently, however, a great deal more research must be directed toward obtaining an understanding of the fundamentals of this phenomenon. We can no longer say positively that the control of some particular insect is a solved problem. The solution may be only temporary, and a shift in the composition of the population may take place, as a result of the application of the recommended treatment, in such a way as to enable the species, after a certain period of time, to escape serious reduction in its numbers by such treatment.

Significance in Insecticidal Control.—It is perhaps in the field of direct control, that is, in the use of insecticides to check a species, that this race phenomenon has its greatest significance in applied entomology. In two striking cases, those of the red scale and the codling moth, the characteristics of a population have changed, as a result of the application of insecticides, so as to make formerly satisfactory treatments largely ineffective. There is every reason to believe that this condition will develop with many other pests, and the economic entomologist can expect to be continually faced with the prospect that many of his recommendations will, in time, become of doubtful value.

The mechanics of race development are such that it is the most intelligent grower, the one who is most painstaking and conscientious in the control of his pests, who will first be confronted with this problem. The region in which a certain pest-control measure is applied most effectively and most generally is the one in which we can expect these population shifts to take place most definitely and most promptly. Is the remedy then to be found in counseling less drastic control measures? We certainly are not yet ready to admit that necessity.

It seems perfectly plain that the first requirement is to obtain a better understanding of the factors which underlie the struggle for dominance between two or more potential races of the same pest when subjected to some specific treatment. We should know the mechanism by means of which one race succeeds and the

other fails. Then we are in a position to consider the remedy in a rational manner. Is the resistance of the red scale determined by some respiratory mechanism? If so, then the alternating of fumigation with some treatment in which this respiratory mechanism is not directly involved becomes a rational procedure; for, as mentioned earlier, there is evidence to indicate that in the absence of fumigation the red-scale population tends to revert to the "nonresistant" type. The Colorado race of codling moth seems to be a more difficult problem, because the ability to enter sprayed apples successfully is only one of its many racial accomplishments. Perhaps it would prove superior under *any* kind of insecticidal treatment, in which case a solution of the problem must naturally be sought in some other direction.

The point is, that, in general, as these populations shift from one race to another, we should be able to alternate the treatment in such a way as to cause them to shift back. This involves a determination of the biological characteristics which enable one race to become dominant over another in the presence of certain pest-control measures. And so the whole problem of "how insecticides kill" grows in importance, and expansion of research in insect physiology becomes a paramount necessity.

Significance in Biological Control.—The significance of insect races is not much less in other fields of pest suppression. The existence of races of the parasite species *Tiphia popilliavora* Roh., differing in reproductive capacity, has been recorded. Conceivably, this might be of importance in the biological control of the Japanese beetle; although one would have to guard against the assumption, *a priori*, that the race having the greater reproductive capacity would necessarily be the more valuable. The opposite would more likely be true. Races of this wasp have also been found, showing an appreciable difference in time of autumn emergence. Clausen (1936) points out that "In this instance a late emerging form should be of much greater value because of the larger number of host grubs which are in the proper stage for attack at the time the wasps are ready for oviposition."

Before the possibilities of the biological control method of pest suppression have been exhausted, the probable existence of races having varying characteristics in parts of a parasite's range will have to be given consideration in connection with the attempt to establish a species in a new habitat. The existence of the New Jersey race of the parasite *Macrocentrus ancylivorus* Roh. has been of utmost importance in the biological control of the oriental fruit moth. This points to the possible importance of distributing stock of native parasites from one part of the country to another, even though the species is widespread, as Clausen (1936) has already suggested.

Significance in Mechanical Control.—The significance of host races must be very great in forest entomology, in which mechanical methods of control are so largely used. If it is possible, in some cases, to control a pest on one host by destroying the insects attacking that particular host and ignoring the populations of the same species of insect occurring on another host in the same region, as seems to have been demonstrated by Hopkins and his associates in connection with the mountain pine beetle, *Dendroctonus monticolae* Hopk., that fact must be of great importance and must have possibilities in many fields other than forest entomology. But our knowledge regarding this is very meager.

Significance in the Breeding of Resistant Hosts.—The selection of the topic "Breeding of Plants Resistant to Insect Attacks" as the subject of our joint symposium this year, indicates the importance that entomologists now attach to this method of pest control. In this work, however, we are certain to be confronted with the problem of racial segregation—the tendency of the insect population to shift in the direction of greater ability to infest the "resistant" host varieties which we are to develop. I have already alluded to Painter's (1930) discovery of two races of hessian fly, differing in their ability to infest different strains of wheat. Just how much of an obstacle this will prove to be, remains for the future to reveal; but if we can judge from the experience encountered in breeding rust-resistant varieties of small grains, it may prove to be a very serious handicap.

Significance in Plant Quarantine.—The existence of insect races may also be of interest in connection with plant quarantine and invokes the following questions:

Should one undertake to prevent the spread of the walnut race of codling moth into a walnut-growing area in which it is not known to occur, but in which the ordinary pome-fruit-infesting race exists? What about attempting to prevent the spread of the resistant red scale into districts where it is not known, but where the non-resistant race is common?

An interesting problem involving this question of races and plant quarantine is just now confronting the California State Department of Agriculture. The cherry fruitfly, *Rhagoletis* sp., is a pest of some importance to cultivated cherries in parts of Oregon. For many years, California has excluded these cherries because cherry orchards in California are free from fruit flies. Recently, however, what is probably the same species of *Rhagoletis* has been found infesting mature wild cherries in California throughout the Sierra Nevada region above an elevation of about 5,000 feet. The practical question which arises, is whether the flies attacking cultivated cherries in Oregon are really the same species; and, if so, whether they are a different race from those attacking wild cherries in California. Should the California quarantine be lifted if the flies prove to be conspecific, which would mean that the same species is found in both states, or is quarantine still justifiable on the ground that the flies in California might be racially different? This question cannot be answered satisfactorily without further research.

These problems emphasize the need for some really basic information on the nature and origin of races in insects. Does any reasonably large population contain the potentiality of *all* the races composing the species, as was suggested earlier in this paper? If so, insect races could largely be ignored in plant quarantine, because the environment would in time automatically segregate and make dominant whatever races were best adapted to the existing conditions. It seems most probable that large populations contain the complete "store of concealed, potential variability" of the species, while in very small populations some lines may be absent. This is only conjecture, however, and real information is needed badly.

CONCLUSION.—We cannot study this question without being impressed by the fact that the tendency to form races is of the greatest practical significance in relation to insecticidal control, to biological control, to medical entomology, to mechanical control, and to plant quarantine. There is probably no important subdivision of applied entomology in which this characteristic of insect populations fails to present itself in one way or another. Indeed, it is much broader than mere economic entomology; for, to quote again from Dobzhansky (1937, p. 120): " . . . the physiology of populations is for the time being the most neglected, although very probably the most essential, part of the theory of evolution."

As economic entomologists, we are not directly concerned with the broad problem of evolution. Nevertheless, as a result of our study of insect populations, we are in a position to make observations which, when followed up by workers in that field, will serve to advance our knowledge of the nature and methods of evolution materially. From a purely utilitarian standpoint, we cannot fully discharge our obligation to society without seeking an understanding of this phenomenon of racial segregation in insect populations and making practical use of the knowledge obtained. The subject is a profound one and needs to be attacked from a fundamental standpoint. Owing to the demand for results of immediate value and the extreme pressure under which most of us have had to work, we have had to forego, largely, the satisfaction of delving more deeply into these fundamental questions. But there are many reasons why that condition cannot be permitted to exist indefinitely.

Everyone, for example, recognizes that the codling moth is becoming harder and harder to control. It appears that unless some sort of relief is provided, large and important acreages of apples will sooner or later go out of production because of this. I am convinced that basically this condition is a result of the presence of racial potentialities in the species *Carpocapsa pomonella*, which make possible a shift in the nature of the population when the latter is subjected to environmental changes involving the presence of insecticides on the host fruit. This shift enables the species partially to overcome the increased environmental resistance and thus to maintain itself at higher population levels.

Unless biologists are entirely wrong in their ideas regarding the interaction of genetic variability and natural selection, these racial shifts are what we should expect to take place. They should be and are, I believe, much more common than is generally realized by economic entomologists. They undoubtedly account for many of the puzzling cases of increasing difficulty of control and for some of the changes observed as taking place in the numerical status of certain species of invertebrate pests. We correctly place great emphasis on the importance of the responses of the individual insect to environmental factors. But the characteristics of insect *populations also* are influenced by the nature of the environment. These influences will not be revealed by studying the response of the individual. Are we not in danger of focusing our vision too intently on the tree, and by so doing failing to see the forest?

This situation presents a challenge to our profession, but it is a challenge which we should be glad to meet. The development of strength and perfection in professions, like that in individuals and in species, comes about only as a result of meeting and overcoming obstacles. Here is an obstacle to the practical usefulness of entomology, the surmounting of which will require not only all our ingenuity, but all our capacity to organize and ability to enlist the active cooperation and interest of geneticists, physiologists, ecologists, and taxonomists. It is my firm conviction that recognition of the practical significance of the effect of man's activities on the racial composition of insect populations, followed, of course, by group attack for solution of the problems arising from it, will become a milestone in the progress of both the science and the art of applied entomology.—12-27-40.

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Status of Plant Quarantine and Inspection Section in the American Association of Economic Entomologists

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This discussion of the question of the status of the Plant Quarantine and Inspection Section in the American Association of Economic Entomologists is not prompted by any thought that there have been new developments that would warrant a different status than existed ten or even forty years ago.

The fact is that there are several societies which include objectives that are useful and even necessary to the advancement of Plant Quarantine work. All of you, certainly will agree that it is not only sound business, but essential that quarantine officers have some organization, in addition to the purely administrative and policy-forming organizations, in which the basic scientific problems pertaining to plant quarantine work can be discussed and integrated with the work of those scientific organizations having the same common objectives and interests.

There is special need for some form of affiliation which will permit the group to maintain its identity, and through which its common interests with the scientific fraternity will be effectively furthered. The Plant Quarantine officers have found this in the American Association of Economic Entomologists.

The mutual interests of the Qurantine Section (formerly known as the Association of Horticultural Inspectors) are grounded in thirty-nine years of integrated association with the American Association of Economic Entomologists. The two have a common purpose; each needs the cooperation of the other. The section on Plant Quarantine is the oldest of seven sections and branches of the Association. The American Association of Economic Entomologists has always been interested in, and supported, Plant Quarantine work and has served the Plant Quarantine officers well.

Every entomologist and plant pathologist realizes the need of close cooperation between research, extension and plant pest control agencies and personnel. Leaders in all these fields are cooperating closely. They have done a tremendous and much needed job of efficiently organizing plant pest work all over the country.

The primary reason for discussing this question is to urge the teachers, the research workers and the extension people to take a more active interest in the affairs of the Quarantine Section. The Quarantine Section is vitally interested in the affairs of all these groups. Not one of these groups, quarantine, teaching, research, or extension, can operate as efficiently and effectively as they now do, without the help, advice and cooperation of the others.

The section on Plant Quarantine, which might be more appropriately called the section on "Plant Pest Control," is one of the key-sections in the Association. It is vital to the balance of Economic Entomology and Plant Pathology. Plant pest control is fundamentally the business end of Entomology and Plant Pathology.

In the early days, when this country was being settled, people were confronted with pest problems. They needed and desired solutions for these problems. Through the medium of colleges and experiment stations, entomologists and plant pathologists were employed. Excellent work was done, but new pests con-

tinued to appear. Relief was still badly needed. Agricultural people lived in fear of new pests from foreign lands and in fear of the spread of dangerous pests already established. The American, being a business man, sensed his needs. Laws were drafted and enacted to provide authority for dealing with the various pest problems. These laws have amply justified their passage, and today plant quarantine and pest control work is established on a sound business basis.

Plant Quarantine work, following its inception, developed with great rapidity. Practically every state in the union enacted a pest law designed to cope with its own problems and needs. These laws naturally varied somewhat in their scope and specific requirements. Because of such differences in State laws there arose a need for administrative cooperation in reviewing and handling the interstate problems that developed in regulatory and enforcement work. As a result of the efforts of this section, these complicated administrative problems are now being handled by regional boards, made up of the administrators from member states and the National Plant Board, which so function as to coordinate the problems of the regional boards as they apply to the nation. The purpose and functions of these boards can probably be best defined by quoting from the 1925 Constitution of the Central Plant Board which says in Article II, "The purpose of this organization shall be to promote uniformity and efficiency in horticultural and quarantine regulations." The purpose of the National Plant Board can well be stated by quoting from a memorandum released by the secretary of the National Plant Board.

"The National Plant Board acts as a country-wide board of review handling problems in regulatory work and plant quarantine enforcement of national interest, and of an insect pest or plant disease nature. It was created at Kansas City, Missouri in December, 1925, after years of study, by the American Association of Horticultural Inspectors, now known as the Section of Plant Quarantine and Inspection of the American Association of Economic Entomologists."

All will agree that quarantine officers have succeeded admirably in their endeavors to restrict the spread, retard the development of, and to suppress the new pests with which they have been so often confronted. At times the work has been extremely difficult because often it is necessary to attack new problems with little or no information on habits, biology, or control of the pest concerned.

RESEARCH WORKERS.—If information on habits, biology and control is not available, only research can make it so. In cases where quarantine action seems essential, about the only thing the quarantine officer can do is to promulgate a quarantine restricting the movement of crops or materials that are likely to carry or transmit the insect or disease beyond the borders of the infestation. This is very undesirable and something which no quarantine officer should do unless it is absolutely essential. It is his duty to provide methods for disinfecting shipments so that they may pass beyond the border of infestation. It is also his duty to assist plant growers and others to produce plants and materials that are free from the insect or disease under quarantine. The methods of disinfection and directions for the production of plants and materials free from the insect or disease in question should be simple, economical, and should be improved from time to time as new knowledge makes this possible.

The research entomologist or plant pathologist has a prolific field for worth while investigations along these lines that will aid the Plant Quarantine officials. The problem of San Jose scale, as old as it is, has not been satisfactorily settled from the nursery inspectors' standpoint. This is particularly true in the south where San Jose scale seriously injures certain broadleaf evergreens that cannot be safely sprayed with the more satisfactory scalecides. We are definitely in need of efficient methods of diagnosing many virus diseases, especially in cases where the incubation period may be one or more years. A quick, easy method of culling the diseased trees from the healthy trees at the time of packing would relieve the quarantine officer of many embarrassing situations. Peach mosaic and the phony peach disease are examples where such information would be most welcomed. The field of chemistry offers real possibilities for this accomplishment. There have been indications of progress with the phony peach disease, but more rapid progress is needed. Medical men are able to diagnose many human diseases by their reaction to chemicals, and our plant pathologists may well be able to accomplish the same for plant diseases sooner or later.

We all realize that there are times when quarantines are absolutely essential, but it seems improbable that they should be continued in perpetuity. Energetic control measures should immediately follow any quarantine action looking toward relief, stabilization, or even the elimination of the pest requiring quarantine action. We must remember that those who have to comply with the quarantine suffer from the quarantine as well as from the pest. Those who live outside the influence of the quarantine restrictions may also suffer, or be seriously inconvenienced because they cannot receive materials needed in their business from the quarantined area. Research is the only solution, and desired results will come quickest as a result of general interest on the part of all research workers.

EXTENSION WORKERS.—All extension entomologists and plant pathologists should actively interest themselves and participate in the affairs of the quarantine section. They work in the field and should be in a position to give quarantine officials frank advice as to both special and general needs. They are advocates of pest control, and as advocates of pest control, must work in cooperation with quarantine officials. Public confidence in both extension work and regulatory work will be increased by the fact that the extension worker has a thorough knowledge and understanding of all plant quarantine problems.

TEACHERS.—I am confident many teachers of economic entomology and plant pathology feel that they do not have any special interest in the quarantine section. This is very unfortunate. Too many teachers, in attempting to place a student who is not adapted to either research work, extension work, or teaching, are inclined to aid the student, and at the same time relieve their conscience by recommending the student for an inspector's job. Those teachers don't understand an inspector's job. Only men qualified by training and temperament should be recommended for quarantine work. A man to be successful in quarantine work must be an executive, a diplomat, possess the qualities of an extension worker, and know the fundamentals of research. Quarantine work can suffer embarrassments and criticisms as a result of misfits in personnel.

THE QUARANTINE OFFICER.—Some of the problems in which the quarantine official must have both the direct and the indirect support of the teacher, research, worker, and extension worker have been pointed out. Quarantine officers should also bear in mind that there are many pressing problems that could be better adjusted by closer cooperation among the officers themselves. Many of these problems are not new, and many of our people, especially the nurserymen, feel that something should have been done years ago to rectify them. These problems pertain to the question of:

1. Uniform certificates.
2. Lack of confidence in the neighbor's ability to inspect and certify properly.
3. Questionable quarantines and quarantines which have the force of embargoes.
4. Fees, licenses, and reciprocal agreement.

These questions are gradually being settled, but our constituents feel that settlement should proceed more rapidly. The late state senator, Orlando Harrison, of Berlin, Maryland, may well be quoted here because he was an outstanding nurseryman and an enthusiastic supporter of quarantine work. As chairman of the committee on uniform inspection of nursery stock for the American Association of Nurserymen, Senator Harrison, thirty-three years ago, addressing this very section, then known as the American Association of Horticultural Inspectors, said:—

> "It was clearly shown in the correspondence which I received that the majority of our nurserymen desire a change in conflicting laws of the various states. They want one inspection, and one certificate which will permit them to ship into the various states."
>
> "It is also clearly shown by their correspondence that something must be done for their relief, as the excessive amount of red tape is expensive under present conditions."

CONCLUSION.—In closing attention may be called to the fact that the scope of quarantine work as related to economic entomology and plant pathology is expanding year by year. The plant quarantine official finds himself not only involved in the problems of quarantine enforcement, legislative enactment, restricting the movement of crops, and the disinfection of shipments, but in keeping his administrative functions on a sound basis, he is also involved in the problems of education and research which include life histories, habits, ecology, chemical control,

biological control, vectors, and intermediate hosts, as well as all the other problems that confront the economic entomologist and plant pathologist. Likewise, all of the economic entomologists and plant pathologists are associated with problems common to the quarantine offices.

Plant quarantine work will always meet three-fold assault.

1. By interests from without the nation which desire to market in the nation without regard for the hazards involved.
2. By interests within the nation which place personal gain and greed above national welfare.
3. By individuals or small groups who, for reasons of a heterogeneous nature, oppose quarantine work. These objections are usually the result of misunderstandings or the lack of knowledge regarding the value of the work. Others may oppose quarantine work because of a *laissez faire* complex or for reasons, personal or otherwise, too numerous to mention.

If we hope to prevent "termite" action from gaining a foothold we must keep all quarantine and regulatory matters on a scientifically practical basis.

Some may feel that all matters pertaining to the field of Plant Quarantine can be effectively and more expediently handled through administrative and policy-forming organizations, as the plant boards and related organizations. These organizations are vital and should be fully supported, but to transfer the opportunities of this organization to any administrative body and deny interested scientists in related fields the privilege and opportunity of open forum would not be in keeping with either public interest or efficient management. Close contact and association with teachers, research workers, and extension people in related fields can only result in more successful regulatory work. Only progress and efficiency can result from the association of groups who have for their goal—a common purpose.—1-17-41.

Bee Poisoning: A Review of the More Important Literature[1,2]

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With the increase in the numbers of organisms attacking plants, there has resulted an ever increasing distribution of chemicals for the control of these pests. In some cases, the method of application is such that the chemicals are applied not only to the plants to be protected, but to the surrounding vegetation as well. When this occurs it may constitute a menace to bees.

The problem of bee poisoning is not a new one. Among the early references to losses of bees through the application of insecticides, may be cited the report of G. M. Thompson (1881) who stated that he applied Paris green to a pear tree in bloom and killed many bees.

At about the same time, there arose a heated discussion concerning injury to grapes by bees. There are many reports of losses of bees caused by their consuming poisoned syrups placed in the vineyards. In 1886, McLain conducted some experiments proving that bees were unable to injure sound grapes. In spite of McLain's work, reports of losses of bees through deliberate poisoning continued to appear for many years.

In the meantime, the question had arisen as to the likelihood of danger to bees through the application of paris green or London purple to bloom. Brose, 1888, fed both of the insecticides listed above in sugar syrups. He reported that the mixtures seemed to repel the bees somewhat, but that those that did feed were killed in from one-half to four hours. In 1889, losses of bees were reported through spraying fruit trees in bloom. Cook (1889) and Webster (1892–96) conducted experiments which proved conclusively that, under field conditions, the application of arsenicals to bloom would kill bees. In spite of this work, the application of insecticides during bloom was to continue for many years.

In 1904, a further danger from the use of insecticides was reported. At that time,

[1] Contribution from the Department of Entomology, Massachusetts State College.

[2] The author wishes to acknowledge his appreciation of the assistance of the following students: G. Erickson, T. Johnson, S. C. Mendall, A. Pava and Fred Smith.

J. A. Green pointed out that poisoned cover crops constituted a serious menace to bees.

Kingsmill (1917) reported experiments with bran, paris green and molasses baits as used against grasshoppers and cutworms. He stated that few bees visited the mixtures. Since that time, there have occurred numerous reports of losses to bees from the use of poison baits.

In 1918, there appeared the first quantitative measurement of the amount of arsenic required to kill a bee. Troop reviewing Price's work reported that a dose of 0.5 microgram was fatal.

In 1920, there appeared the first well planned study of the effects of arsenicals on bees. Price conducted both laboratory and field studies. According to this worker less than 0.5 microgram of arsenic was the fatal dose. In one instance, Price reported that bees confined to a tree dusted with lead arsenate and sulfur suffered less loss than bees exposed to a tree sprayed with lead arsenate and lime sulfur. The writer is of the opinion that this result was due to the fact thst the colony exposed to dust was twice as strong as the one exposed to spray.

In 1921, Parks reported the loss of bees through the application of an arsenical weed killer along the right of way of a railroad. In this instance an apiary of fifty colonies was destroyed.

Melander (1921) made a study of the problem of poisoning under orchard conditions. He indicated that poisoned cover crops were the principal source of danger in fruit districts. Due to an increased use of cover crops producing nectar or pollen, Melander stated that spray poisoning was becoming more serious and widespread. He indicated that dew collected from poisoned foliage would kill bees. This worker also included data on the first comprehensive study of repellents.

Doane (1923) published the results of some experiments that he had conducted in California. From these experiments, Doane concluded that there was no danger to bees from an application of lead arsenate applied during bloom. An examination of his data reveals many peculiar conditions.

The same year, McIndoo published a paper indicating that neither the application to cotton of a calcium arsenate dust nor the use of calcium arsenate-molasses bait was likely to injure bees seriously. In the light of subsequent reports, it appears that such observations do not hold true under many conditions.

In 1926, McIndoo & Demuth reported the results of experiments, under orchard conditions, covering a period of several years. Poisoned pollen proved to be the principal source of danger They stated that bees work on the sprayed foliage as well as on the unsprayed According to these workers, the fatal dose of arsenic, expressed as metallic arsenic, was 0.4 to 0.5 microgram per bee. A final point was that when trees were sprayed after 90 per cent of the blossoms had fallen, little or no poisoning occurred. This observation might be influenced by various factors, including the presence of bloom, other than apple, that might be poisoned; whether or not the bees had access to a supply of water, and weather conditions.

Hilgendorf & Borchert (1926) reported that serious losses resulted from the application of arsenicals by airplane to control the nun moth in Europe.

In 1927, Bourne reported that nicotine sulfate acted as a repellent to bees. Blossoms sprayed with a mixture of lead arsenate, lime sulfur, and nicotine sulfate were not as attractive to bees as were unsprayed ones. Bourne believed that if the materials were applied at the right time there was little danger to bees not restricted in flight.

Borchert (1930) investigated the effects of copper compounds on bees. From his data, he concluded that a dose of 9 micrograms of copper was lethal.

In 1933, Herman & Brittain published a thorough report analyzing the effects on bees of fungicides and insecticides as used under orchard conditions. Some of the conclusions drawn in this report follow:— 1. Poisoned pollen is the principal source of danger to bees and brood. 2. Water from sprayed foliage may be a very important source of danger. 3. The incidence of poisoning is affected by weather conditions. 4. With the presence of more than .04 microgram of metallic arsenic per bee, poisoning may be expected.

Webster & Crews, 1934, reported heavy losses to bees in the Yakima Valley. These were occasioned by application of arsenical sprays to potatoes. They recommended that some poison other than lead arsenate be used. Calcium arsenate or some fluorine compound was suggested.

In 1934, Hoskins & Harrison stated that a fatal dose of arsenic, as elemental arsenic, was between 0.1 and 0.2 microgram.

Himmer (1934) pointed out the danger to bees of the application of insecticides in dust form. He stated that a danger zone of three or six miles exists in the neighborhood of crops dusted by means of power dusters or airplanes.

In 1935, Dobrosky, as a result of feeding experiments, concluded that, on the basis of the time necessary to produce mortality, both natural and synthetic cryolite are more dangerous to bees than is lead arsenate.

Hildebrand & Phillips (1935) stated that copper sulfate acts both as a repellent and as a toxic agent to bees. From their tests, they conclude that it is impossible to predict the damage which might result from an application of copper sulfate to fruit bloom. Their result indicates that copper sulfate at the rate of two pounds to fifty gallons of water is poisonous to bees.

Eckert & Allinger, in a series of papers from 1935 to 1937, discussed the danger of the airplane dusting to bees. Their evidence shows clearly that the application of poison dusts by airplane is an extremely dangerous practice so far as bees are concerned. They include a discussion of measures that might be used to solve the problem.

Filmer (1937) reported the loss of bees which he attributed to an application of a combination dust containing rotenone.

Hambleton (1939) stated that particle size affects the toxicity to bees of cryolite, lead arsenate and calcium arsenate. Cryolite having a median particle size of 2 microns was about three times as toxic as the same material having a median particle size of 28 microns.

In 1939, Shaw & Mendall made a survey of the opinions of research workers, apiary inspectors, and teachers of apiculture as regards the status of bee poisoning. Eighty-two per cent of those receiving questionnaires, 65 in all, replied. The opinion of the majority is that poisoning is increasing.

This completes the general survey of the more important references dealing with bee poisoning by insecticides and fungicides. Some of the problems which appear important at present in this Section may now be discussed. These include the effects of rotenone, pyrethrum, and sulfur on bees, and the use of repellents.

ROTENONE COMPOUNDS.—Ginsburg, (1932) made a study of the effects of rotenone as a contact spray. The material used contained an acetone extract of 3 per cent rotenone. At dilutions of 1 to 400 and 1 to 800, a mortality to bees of 100 per cent and 69.6 per cent, respectively, in 24 hours was recorded.

Gerard (1935) reported the death of bees caused by an application of derris to raspberry blossoms. Both adults and brood were killed. Gerard believed that the derris interfered with respiration.

Tischler (1935) exposed honeybees to a stream of air passing over derris extract and over derris powder. As a result of his experiments, he concluded that derris does not emit a vapor toxic to bees.

Filmer (1937) presented data indicating that derris or rotenone dust was toxic to bees. The evidence is not too clear, since the dust contained, in addition to 0.75 per cent rotenone, also sulfur and copper. He fed rotenone syrup mixtures at dilutions of 1 to 317, 1 to 625, 1 to 1250, and 1 to 2500 to bees. All died within 72 hours except at the dilution of 1 to 2500. Filmer concluded that the use of rotenone derris dusts on agricultural crops may be a serious source of poisoning.

Böttcher (1939) reported that derris acts both as a stomach and as a contact poison, but not as a respiratory poison, to bees. He stated that the minimum lethal dose varied between 0.5 and 11 micrograms, depending on the temperature and the individual. Three micrograms was the average dose. Böttcher concluded that under field conditions the concentrations usually applied had no serious effects on bees.

It is evident that our present information concerning the effects of rotenone on bees is both scant and conflicting. Since the present indications are that this insecticide is to be used more and more, it would appear necessary to conduct further experimental work on this matter.

PYRETHRUM COMPOUNDS.—Ginsburg (1929) stated that pyrethrum in the form of an alcoholic extract of the flowers ranks very high as a stomach poison to bees. He recorded a mortality of 100 per cent in 24 hours, using 1 to 4250 dilution of this material.

In 1930, the same investigator exposed bees to pyrethrum fumes for 48 hours. At the end of that period the insects appeared perfectly normal, thus indicating that the pyrethrum does not emit a vapor toxic to bees.

Ginsburg & Schmitt (1932) sprayed bees with a solution containing an acetone extract of pyrethrum. At a dilution of 1 to 800, actual pyrethrin 1 to 88,000, they obtained a kill of 84.5 per cent in 24 hours. The checks showed a mortality of not over 2.4 per cent during the same time. The authors conclude that at low concentrations pyrethrum is more toxic than rotenone as a contact poison to bees.

Böttcher, 1938, reported that pyrethrum acts as a powerful stomach poison to bees. He noted that temperature affects the toxicity of the compound, a higher dose being required at the higher temperatures. He reported a median lethal dose of 0.05 microgram of pyrethrins at 20 degrees C. As a result of field experiments, Böttcher concluded that at the dilutions used, 0.2 to 0.009 per cent pyrethrins, pyrethrum dusts and sprays cause only slight losses of no practical importance.

Filmer[1] reported some cases of contact poisoning through the use of pyrethrum compounds in the control of cranberry insects.

Doehlert (1940) reports that no cases of serious destruction of bees through the use of pyrethrum on cranberry bogs have been observed.

In view of present information it would seem that, as with rotenone, experiments should be conducted to determine the effects of pyrethrum sprays and dusts on bees.

SULFUR COMPOUNDS.—The use of sulfur has been recommended in the past as a control measure against certain bee diseases. There appear to be slightly contradictory reports as to the safety of such treatments, depending in part on how the sulfur is administered. Cox (1916) fed sulfur syrup to bees and reported good results in the control of the disease attacking his bees. Davis (1916) dusted bees and brood with sulfur and killed both.

Herman & Brittain (1933) reported as follows concerning application of sulfur to apple trees during bloom:

"Sulfur applied in the form of sulphide sprays or elemental sulphur in the form of a dust causes pronounced dysentery. In tent experiments a certain amount of mortality was caused but under field conditions it is believed that most of the bees recovered. Feeding tests indicate that considerable mortality may be caused by unpoisoned sulphur dusts but not comparable to that caused by arsenicals."

The author, in some preliminary experiments, fed bees a wettable sulfur at the rate of five pounds to one hundred gallons of water in a 50 per cent sugar syrup. While some mortality occurred, many of the bees that had fed as many as three times on the mixture were alive fourteen to eighteen days later. When given a choice of sulfur syrup or plain syrup they fed on the latter, but when given the sulfur syrup alone they consumed it readily. The same kind of sulfur was then dusted lightly over combs containing unsealed brood. When sulfur particles entered the cells so that they could be seen on the larvae there ensued a considerable mortality. The same experiment was repeated, using an observation hive. Similar results were obtained. Moreover, it was noted that eggs failed to hatch if sulfur was present in small amounts in the cells.

In some sections, there seems to be an increase in the use of sulfur sprays and dusts during bloom, for control of apple scab. In view of this, we should have more definite information as to the effects of sulfur on bees. Such studies should include experiments to determine the effect of sulfur mixed with pollen, on brood. This problem is a difficult one, due to the many kinds of sulfur and the variation in particle size of sulfur compounds, now in use.

REPELLENTS.—As early as 1900, it was suggested that the problem of bee poisoning might be overcome by the use of some material, in a spray, that would repel bees, Callbreath (1900) recommended the use of carbolic acid as the repellent.

Numerous scattered reports appeared from then on. Not until 1921 was there any detailed study of this problem. In that year, Melander (1921) reported that, from feeding studies, both cresol compounds and carbolic acid were very repellent. Carbon disulphide, nicotine sulfate, and naphthalene were also quite repellent.

Morse (1921) reported that the use of *Milkol* had reduced losses to bees through

[1] Unpublished correspondence, 1939.

shade tree spraying. In 1923 (Morse 1923), she stated that *Milkol* was still high in her opinion, in spite of the fact that investigators at Washington State College claimed that the repellency was lost in a short time.

Bourne (1927) reported that nicotine sulfate acted as a repellent to bees.

Vecchi (1931) stated that carbolic acid was not effective as a repellent.

Southwick (1938) recommended the use of one pint of creosote per one hundred gallons of spray solution.

The writer, with the cooperation of some of his students, conducted some preliminary tests with possible repellents. Included were creosote, tar oil, phenol compounds, *Milkol*, naphthalene, and alpha and beta naphthols. These materials were used in combinations of spray materials or dusts such as might be used under orchard conditions. While the number of observations was few, the evidence showed that each of these materials did decrease the number of visits as compared to those made by the bees to untreated blossoms. However, all *Milkol* combinations produced from slight to moderate blossom injury. The creosote and tar oil compounds produced severe blossom injury and would not be suitable for orchard use.

Further studies of repellents should take into account the following: 1. Effect of repellent, alone or in combination, on the plant. 2. The duration of repellency. 3. That the repellent substance must be one which will mix readily with the spray or dust and remain well distributed. Creosote, for example, is difficult to get into solution. It seems clear that the study of repellents should be investigated further before conclusions are reached.

By way of conclusion, the belief may be stated that a well standardized project of major proportions should be established to obtain information on the many phases of bee poisoning. The following factors contribute to this conclusion: 1. The close inter-relationship between beekeeping and various agricultural enterprises. 2. The diversified agricultural practices in different sections of the country. 3. The increased use of chemicals to control insect and other pests. 4. The development and use of new chemicals, together with improved forms of the old ones, to control insects. 5. The practice, in some areas, of applying chemical materials without regard to their distribution and the possible danger to forms of life other than the one for which the control measures are intended.—1-7-41.

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Alfalfa Nectar and the Honeybee*

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Alfalfa, which is grown extensively in the West for hay, forage, and seed, is also the chief source of honey in numerous places. But even where it is grown under irrigation and is allowed to blossom, the honey crop, for various obscure reasons, is not assured. Likewise, a crop of seed is rather unpredictable. To throw some light on this subject, observations have been made on alfalfa nectar, both under controlled conditions in the greenhouse and in the field.

GREENHOUSE STUDIES.—The studies under greenhouse conditions were made during the winter and spring of 1939–40 at Davis, Calif. Exposure of alfalfa plants to artificial light from ordinary bulbs from 5 P.M. to 10 P.M., as a supplement to daylight, brought some of them into blossom early in the winter. Plants not so treated did not flower until late in April, that is, no earlier than the plants out of doors. The average number of blossoms on a raceme was 16, with a range from 11 to 25. The blossoms at the tip of a raceme opened about 4 days later than the first ones to open at the base. In the open greenhouse each blossom withered in about 7 days, but under a humidifier the life of blossoms was much extended. Natural tripping of these blossoms was not noted.

* A contribution from the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, in cooperation with the University of California.

In the greenhouse the nectar could be collected by hand, since insects did not deplete the supply. A tiny glass pipette, connected by a rubber tube to a low-pressure breath-operated vacuum pump, was used to draw nectar from individual blossoms into a composite sample.

Variation in the soil moisture resulted in a range of about 27 per cent in the concentration of sugar in nectar from flowers on uncut stems continuously exposed to a saturated atmosphere, and there was nearly the same range on the stems not under the humidifier. The data in table 1 indicate that soil moisture as well as air moisture influenced the sugar concentration in the nectar. Other flowers on stems cut and placed in water under a humidifier showed a drop from the original 50.3 per cent to 37, 30, 16, and 10 per cent on four consecutive days. A single common plant was used in this experiment.

Table 1.—Nectar sugar in alfalfa grown in the greenhouse under various conditions of soil and air moisture, May 1939.

Condition of Soil	Time After Last Watering	Stems in Open Greenhouse		Stems Under Humidifier at Saturation
		Relative humidity	Sugar concentration	Sugar concentration
	Days	*Per cent*	*Per cent*	*Per cent*
Wet	1	58	46.7	—
Dry	5	65	55.0	21.4[1]
Very dry	7	56	67.1	38.3
Wet	1	60	57.2	19.3
Fairly wet	2	60	59.1	11.0
Wet	1	56	48.3	14.3
Average	—	—	55.6	20.9
Check[2]	—	—	47.3	—

[1] Under humidifier for 20 hours. After this time these stems were continuously in the humidifier.
[2] A normally watered Common plant in the open greenhouse.

According to reports from beekeepers in the Rogue River and Klamath Falls areas of Oregon, some varieties of alfalfa are more attractive to bees and more productive of honey than others. Two varieties upon which tests were made in the greenhouse, Turkestan and Common, showed a difference in sugar concentration of the nectar (Table 2).

In four tests with Common and Turkestan the quantity of nectar collected ranged from 0.83 to 2.4 microliters per blossom. On the basis of these data, the number of alfalfa blossoms required for a bee-load of nectar is from 15 to 45. The larger blossoms, especially noticeable with the Turkestan plants under observation, contained the most nectar.

Under continuous warmth in the greenhouse alfalfa never failed to secrete nectar whereas out of doors it was well into May before the blossoms showed evidence of nectar. The early blossoms (April) had no visible supply. According to reports from numerous producers in the San Joaquin-Sacramento Valley of California, only the hot, dry periods afford much surplus alfalfa honey.

FIELD OBSERVATIONS.—Field observations in California, Oregon, Idaho, Nevada, and Utah have shown various relationships between alfalfa blossoms and the activity of honeybees. In most sections bees were only rarely observed gathering pollen from alfalfa. In the Imperial Valley, however, there were numerous pollen collectors. The apparent scarcity of other pollen sources may be the explanation of this exceptional activity. In this instance the bees' mouth parts were extended upward into a blossom for removing the pollen without tripping. The bees were clearly reaching in the direction opposite to the one in which they ordinarily collect nectar from the base of the flower. Only a few alfalfa blossoms visited by bees for either pollen or nectar were observed to be tripped.

Table 2.—Sugar concentration of nectars from Common and Turkestan alfalfa in a greenhouse.[1]

Temperature at Time of Sampling	Relative Humidity at Time of Sampling	Average Sugar Concentration of Nectar[2]	
		Common	Turkestan
	Per cent	*Per cent*	*Per cent*
83–84°F.	48	50.6	62.6
80	57	53.5	63.7

[1] There is no assurance that soil moisture was the same. Each plant was watered at the same time every other day.
[2] All readings taken at 70°F.

Nectar-gathering honeybees were frequently most numerous in the drier spots within and at the margin of an alfalfa field. Blossoming was usually more advanced in such places. These observations are in accord with the data obtained in the greenhouse studies.

Other insects present in a field also influence nectar quantity and the activity of honeybees. Judging from field observations, when thrips are unusually abundant in the blossoms, the quantity of nectar is diminished and visiting bees are reduced

in numbers. A correlation between the presence of many alfalfa butterflies, a reduction in number of honeybees, and the size of the honey crop is frequently reported. Abnormal growth of alfalfa plants and partial or almost complete failure to blossom successfully occur under heavy infestation of *Lygus* bugs. In this case a tained were in commercial seed areas—perhaps only a coincidence.

CONCLUSIONS.—Observations in the field, as well as under controlled conditions in the greenhouse, indicate that alfalfa nectar secretion and the sugar-concentration values are affected by several factors, as follows: A longer light day

Table 3.—Sugar concentration in alfalfa nectars collected in the field.

LOCALITY	NATURE OF FIELD	DATE COLLECTED	SAMPLES	SUGAR CONCENTRATION[1]	
				Range	Average
			Number	*Per cent*	*Per cent*
Oregon:					
Corvallis	Bottom-land	July 1937	37	33–48	42
Union	Unirrigated	July 1938	25	42–58	51
Nevada and Idaho, various localities	Irrigated	1932–1938	Many	—	40
Utah:					
Logan	Wet ditch bank	June 1940	11	34–46	40
Ogden	Hillside, dry in spots	July 1940	21	58–65	62
California:					
Davis	Irrigated orchard; bees scarce	July 1939	9	28–44	34
		Sept. 1939	11	22–30	24
Ripon	Irrigated	Sept. 1939	18	30–46	41
Brawley	Heavy silt, very dry	June 1939	42	52–66	62
	Light soil, lower, wet end of field	June 1939	80	25–41	31
	Light soil, upper, dry end of same field	June 1939	8	37–51	48

[1] The values are approximate, since corrections were not made for temperature variations.

large proportion of the immature racemes cease developing or the flowers quickly turn yellow and drop off.

Samples of nectar from bees visiting alfalfa blossoms showed a decided variation in sugar concentration depending on location and other factors (Table 3). In the Willamette Valley of Oregon, for example, an average value of 42 per cent was obtained, while at Union, in eastern Oregon, the average was 51 per cent. Likewise in northern California the averages ranged from 24 to 41 per cent, but on the heavy drier soils of Imperial Valley the average was 62 per cent. The highest values obstimulates earlier blossoming and thereby lengthens the seasonal nectar secretion period in alfalfa. The Turkestan variety yields more and richer nectar than does the Common. The larger blossoms provide the most nectar. Continuous warmth under greenhouse conditions results in maximum secretion. Sugar concentration is increased by lowering soil moisture, and also by lowering the relative humidity of the atmosphere.

As has been shown in previous work with other honey-producing plants, the bees select the richer alfalfa nectars in their collecting.—1-7-41.

ENTOMOLOGISTS NEEDED BY FEDERAL DEPARTMENT OF AGRICULTURE

An examination for entomologists in taxonomy has been announced by the United States Civil Service Commission. The salary is $3,200 a year and appointment will be made in the Bureau of Entomology and Plant Quarantine in the Department of Agriculture.

Applications must be on file in the Office of the Commission not later than April 10, 1941.

Studies on Toxicity to Honeybees of Acid Lead Arsenate, Calcium Arsenate, Phenothiazine, and Cryolite[1]

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The incidental poisoning of honeybees resulting from the use of insecticides to control harmful insects on fruit trees and other economic plants has long been recognized as a serious problem. The desire for more data concerning the effect of various insecticides on bees, with the hope of finding one that might be fairly harmless to them while being highly toxic to obnoxious insects, particularly the codling moth, prompted the initiation of this investigation in the summer of 1935.

TOXICITY WITHOUT REFERENCE TO PARTICLE SIZE.—The first tests were made with chemically analyzed commercial samples of acid lead arsenate, calcium arsenate, and phenothiazine without consideration of particle size. Bees for the experiments were collected at the entrance of the hives. An effort was always made to get guard bees, not those that seemed to be going in or coming out. In this way a fairly uniform test animal was obtained, that is, one of middle age which had lived long enough to come into full vigor but which had not been worn out by field duty. Tests on the longevity of bees of known age (not yet published) had shown that neither very young nor very old bees are suitable, but that otherwise, owing to natural variation, one is about as good as another.

The bees were brought into the laboratory and fed one at a time, within the next hour or so, from a capillary 1 cc. pipette graduated in hundredths, a measured amount of sugar sirup (60 to 65 per cent sucrose by weight, 2.3 to 2.5 molar)[3] containing in suspension the desired amount of one of the insecticides to be tested. After having taken this dose, each bee was allowed to satiate itself completely with pure sugar sirup before being placed in a cage with other bees, to avoid its being fed regurgitated food from other bees, as often happens if it is hungry. The concentrations of the insecticides in the doses were such that the desired amounts could be fed in volumes ranging from 0.005 to 0.04 cc. No wetting agent was used except for phenothiazine to which 0.05 per cent of saponin was added.

All bees receiving a given dose of insecticide at one time were placed together in a cage, these constituting a lot. A lot consisted usually of 25 to 50 bees. The cages measured 6×3.25×0.75 inches inside; they were constructed of wood, eighth-inch mesh galvanized wire screen, and galvanized sheet metal, and had two holes in the top into which could be inverted small screw-cap bottles, one for water and the other for sugar sirup.[4] The caps of the bottles were made of aluminum and were perforated with five small holes through which the bees could insert their tongues.

Control lots consisted of bees caught in the same way as the test bees but fed no insecticide. These were placed at once in the cages and given free access to water and sugar sirup.

The cages were placed in an incubator and kept at a temperature of 83 to 85°F. Relative humidity in some experiments was uncontrolled, in which case it usually stayed around 60 per cent. In most experiments, however, it was controlled and kept at about 40 per cent, since low humidity has been shown by other Bureau workers (Woodrow 1935) to be conducive to greater longevity in caged bees. The control of humidity was effected by keeping inside the incubators large pans of calcium chloride solution at sufficient concentration to absorb all air moisture in excess of the percentage desired.

The cages in some experiments were examined daily until all the bees were dead, and thus the average longevity of the lot could be computed. In other experiments

[1] A contribution from Western Maryland College, Westminster, Md., in cooperation with the Bureau of Entomology and Plant Quarantine, U. S. Department of Agriculture.

[2] Grateful acknowledgment is given to E. H. Siegler, of the Division of Fruit Insect Investigations, Bureau of Entomology and Plant Quarantine, for much helpful advice during this investigation, to Jas. I. Hambleton, in charge of the Division of Bee Culture, Bureau of Entomology and Plant Quarantine, for advice and constant friendly cooperation, and to R. C. Roark and other members of the Division of Insecticide Investigations of the same Bureau, for the samples used, the data concerning their composition and particle size, and the arsenic determinations on the suspensions of arsenicals in sugar sirup.

[3] This concentration of sugar sirup had a threefold advantage: (1) It is readily taken up by bees in large quantities (Betts 1930), (2) it does not easily ferment, and (3) its high viscosity helps to counteract the tendency of the particles of the insoluble insecticides used to settle out and cling to the sides of the pipette.

[4] The cages were designed by Jas. I. Hambleton and made in the shops of the Beltsville Research Center.

the number dead at the end of 72 hours was the only measure of toxicity noted. However, because of the considerable variation in the longevity of bees even when given the same dose, or no dose at all, the mortality at the end of three days is much the more reliable criterion, and is therefore used mainly in the present paper.

Little difficulty was experienced in getting the bees to take the various dosages of the two arsenates used. With the phenothiazine suspensions, however, considerable repellent effect was evident, and many bees were tried which would not take as much of the material as was required, especially of the more concentrated suspensions.

The question arose as to how much of the suspended material settled out and stuck to the sides of the pipette as it was being administered. Two things tended to minimize this: The concentrated sirup had such high viscosity that settling was considerably retarded, and the pipette was rotated through 180 degrees every few minutes to keep the material inside stirred up. Nevertheless, to ascertain if much settling out occurred, the following experiment was made:

Weighed amounts of calcium arsenate and lead arsenate were each thoroughly mixed with measured amounts of 65 per

Table 1.—Actual amounts of arsenic delivered by pipette in various doses as compared with the theoretical 0.80 microgram in each dose.

Insecticide	Volume Absorbed per Paper in cc.	Grams Insecticide per 100 cc. of Sirup	Arsenic Recovered Mcg. per Paper*	Per Cent Loss
Calcium arsenate (medium)	0.005	0.06584	0.72	10.0
	0.040	0.00823	0.77	3.8
				Av. 6.9
Calcium arsenate (coarse)	0.005	0.05063	0.78	2.5
	0.040	0.00633	0.74	7.5
				Av. 5.0
Lead arsenate (fine)	0.005	0.07805	0.74	7.5
	0.040	0.00976	0.78	2.5
				Av. 5.0
Average			0.757	5.4

* Average for 30 pieces of filter paper for each dose.

Table 2.—Mortality of honeybees after being fed specified doses of various insecticides.

Dose, Micrograms per Bee*	Acid Lead Arsenate				Calcium Arsenate	Arsenic Pentoxide	Phenothiazine
	Average Life, Days	Per Cent Bees Dead After—					
		1 day	2 days	3 days	Per Cent Dead After 3 Days		
0	16.24	0.1	0.4	1.4	1.4	1.4	1.4**
0.0125						0	
0.025						21	
0.05	13.07	0	0	0	0		
0.1	8.35	0	3	5	1	4	
0.2	12.21	0	0	0	0	2	
0.4	10.03	0	0	1	0	10	
0.8	11.30	0	0	0	88	43	
1.6	10.84	0	0	2	100	100	
3	7.13	0	3	11			
4							0
6	6.56	1	2	18			
8							1
12	3.79	0	17	41			
16							0
24	1.39	29	85	97			
36							0
48	0.91	60	99	100			
71							0
140							0
280							2
570							0

* For the arsenicals dose is expressed in terms of elemental arsenic. In acid lead arsenate and calcium arsenate account was taken both of the actual chemical assay of the sample and of the percentage lost through settling out and adhering to the sides of the pipette (Table 1). For phenothiazine dosages are expressed in terms of the total compound, corrected for 0.1 per cent impurity but uncorrected for settling out and adhesion.

** Grouped data from 23 lots of controls.

cent sugar sirup. Then a sample of each misture was sucked into the pipette that had been used in feeding the bees, and with the pipette held in the same horizontal position and rotated at the same interval small doses were drawn out by capillary attraction onto small pieces of filter paper held against the tapered end of the pipette. The papers were assayed chemically for total elemental arsenic.

thiazine are presented in table 2, and the data for calcium arsenate and lead arsenate are summarized graphically by mortality curves in figure 1. By noting where each mortality curve crosses the 50 per cent line, a value for the median lethal dose can be established.

Calcium arsenate proved to be more than 20 times as toxic to bees as lead arsenate, the median lethal dose of the

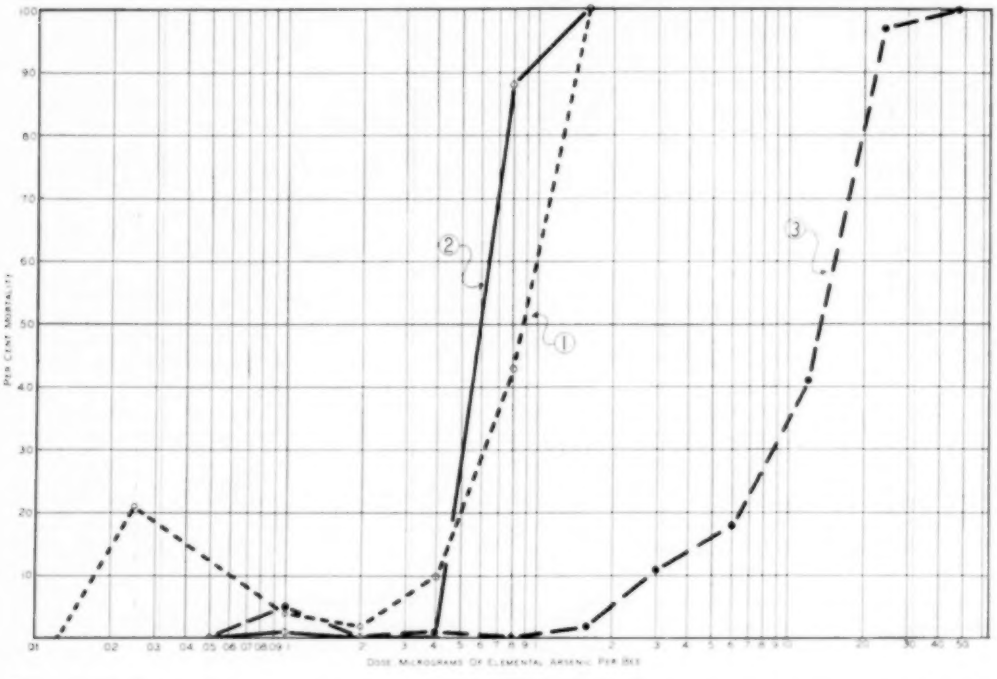

FIG. 1.—Relation between size of dose and the mortality of honeybees within a 3-day period, when the insecticides fed were (1) arsenic pentoxide, (2) commercial calcium arsenate, and (3) acid lead arsenate of unclassified particle size.

The results of these tests are given in table 1. They show in general that the loss was about 5 per cent. It appears to have made no significant difference whether a relatively small amount having a relatively high concentration was used or a larger amount having a lower concentration; in some cases the former showed more loss, in others the latter. Although the results show a somewhat smaller loss for medium material than for coarse, contrary to expectations, and a smaller loss for lead arsenate than for calcium arsenate, the difference is probably not great enough to be significant in either case.

The results of the toxicity tests on lead arsenate, calcium arsenate, and phenothiazine are presented in table 2, and the data for calcium arsenate and lead arsenate are summarized graphically by mortality curves in figure 1. By noting where each mortality curve crosses the 50 per cent line, a value for the median lethal dose can be established.

Calcium arsenate proved to be more than 20 times as toxic to bees as lead arsenate, the median lethal dose of the former being approximately 0.6 microgram of elemental arsenic, that of the latter 13 micrograms. Phenothiazine can hardly be called toxic at all, since the relatively enormous dose of 570 micrograms caused no deaths within three days.

The mortality curve for calcium arsenate is much steeper than that for lead arsenate. Apparently the bees have very little range of tolerance for calcium arsenate, the dose required to kill a small percentage of the lot being only slightly smaller than the dose sufficient to kill the entire lot. With lead arsenate, however, the dose required to kill the entire lot in 3 days was several times that required to kill 10 per cent.

To determine how the relatively insoluble lead and calcium arsenates compare in toxicity with an entirely soluble arsenical, several tests were run with arsenic pentoxide (Table 2 and Fig. 1). This material had about the same toxicity as calcium arsenate. It may therefore be concluded that the calcium arsenate used in these tests was soluble enough, either in the sugar sirup or in the juices of the bee's gut, so that practically its entire toxic principle acted on the bees that ate it.

pipette, exactly as described in the previous section. Essential data as to the size of the particles and the chemical composition of the fractions are given in table 3. Further data may be found in the paper by Siegler & Goodhue.

It will be noted that the percentage of arsenic in calcium arsenate varies in the different fractions. Caclium arsenate is not a pure substance but a mixture containing calcium hydroxide and calcium carbonate along with perhaps several kinds of cal-

Table 3.—Physical and chemical data concerning the samples of acid lead arsenate, calcium arsenate, cryolite, and phenothiazine used in the tests.

INSECTICIDE	DIAMETER OF MID-SIZE* PARTICLES, MICRONS	PER CENT BY WEIGHT OF ACTIVE INGREDIENT		PER CENT BY WEIGHT SOLUBLE IN WATER
Acid lead arsenate:				
Fine	<2	Elemental arsenic	20.5	0.0005
Coarse	18		21.2	0.0005
Calcium arsenate:				
Fine	3		19.8	3.0
Medium	4.5		24.3	9.7
Coarse	28		31.5	18.8
Cryolite:				
Fine	2	Elemental fluorine	55.1	0.043
Medium	8		53.3	0.043
Coarse	28		52.2	0.043
Phenothiazine:				
Fine	4	Insoluble in petroleum ether	98.8	Very slight
Medium	15		97.8	Very slight
Coarse	45		98.2	Very slight

* Defined as that size of particle which divides the sample into two equal parts by weight.

TOXICITY IN RELATION TO PARTICLE SIZE.—While the tests previously described were in progress, Goodhue & Smith (1936) and Goodhue & Cassil (1938) began the work of separating insecticides into fractions of different particle size, and Siegler & Goodhue (1939) tested various fractions for their toxicity to codling moth larvae. Since the fate of honeybees is closely linked with the fate of codling moths in apple-orchard regions, it seemed desirable to carry this investigation on into the relation of particle size to the toxicity of these materials for the honeybee.

Accordingly, samples of acid lead arsenate, calcium arsenate, phenothiazine, and cryolite (sodium fluoaluminate) in different particle size were obtained. Each was suspended in 60 to 65 per cent sugar sirup and fed to bees individually by

cium arsenate, and in the operation of an air classifier such as was used to fractionate this material there results an unequal distribution of these materials in the various fractions. The percentage of active ingredient was taken into consideration in calculating the dosage, as was also the percentage of loss due to settling out and adhering to the sides of the pipette.

The coarse lead arsenate was made in the laboratories of the Division of Insecticide Investigations, since no commercial material contains enough large particles to permit a fraction of this size to be obtained.

Lead Arsenate.—The results for the tests on acid lead arsenate are presented in the first three columns of table 4. Mortality curves from these data are presented in figure 2, together with the curve for commercial lead arsenate taken from

Table 4.—Mortality of honeybees 3 days after a specified dose of a designated insecticide of classified particle size.*

Acid Lead Arsenate			Calcium Arsenate				Phenothiazine				Synthetic Cryolite			
Dose,† Micrograms Arsenic Per Bee	Per Cent Dead		Dose,† Micrograms Arsenic Per Bee	Per Cent Dead			Dose,† Micrograms Phenothiazine Per Bee	Per Cent Dead			Dose,‡ Micrograms Fluorine Per Bee	Per Cent Dead		
	Fine	Coarse		Fine	Medium	Coarse		Fine	Medium	Coarse		Fine	Medium	Coarse
0.2	0	—	0.4	3	0	0	35	1	0	—	2.2	0	—	—
0.4	0	—	0.5	15	14	—	70	20	0	4	2.6	4	—	—
0.9	17	—	0.6	32	43	4	78	0	—	—	2.9	4	—	—
1.5	38	0	0.7	48	76	—	106	—	0	—	3.5	8	0	—
1.9	24	—	0.8	62	100	8	141	94	59	26	3.7	13	—	—
2.3	24	—	0.9	100	83	24	157	0	—	—	3.8	13	—	—
2.5	28	—	1.0	—	100	20	211	—	0	—	3.9	21	—	—
2.9	39	0	1.1	—	100	20	235	0	—	—	4.0	46	—	—
3.2	34	—	1.2	—	100	—	282	—	0	4	4.1	50	8	—
3.7	38	—	1.3	—	100	33	563	—	—	0	4.4	78	—	0
4.6	36	—	1.5	100	—	100					4.7	—	13	—
4.9	56	—	1.9	—	—	96					5.0	—	15	—
5.3	60	—	2.3	—	—	100					5.2	—	29	—
5.8	43	—	3.0	100	—	100					5.4	—	54	—
6.2	60	—	6.1	100	—	100					5.6	—	46	—
6.6	68	—									5.9	88	54	0
7.1	80	—									6.4	—	75	—
7.7	72	—									6.6	—	—	0
9.2	77	—									8.8	94	100	4
12	87	0									9.4	—	—	8
15	100	—									10	—	—	13
20	100	—									11	—	—	33
23	95	—									12	—	—	42
48	—	8									13	—	—	38
96	—	14									14	—	—	63
140	—	56									18	100	100	67
190	—	44									23	—	—	71
240	—	60									35	100	100	88
290	—	92									71	100	—	100
350	—	100									140	100	—	—

* The number of bees fed each of the dosages ranged from 11 to 200, but was usually 25–50. Numerous lots of controls run during the course of these tests gave in no case a mortality of more than 4 per cent in 3 days.

† The volume of sugar sirup used to suspend each dose ranged from 0.01 to 0.04 cubic centimeter.

‡ The volume of sugar sirup used in each dose was 0.01 cubic centimeter.

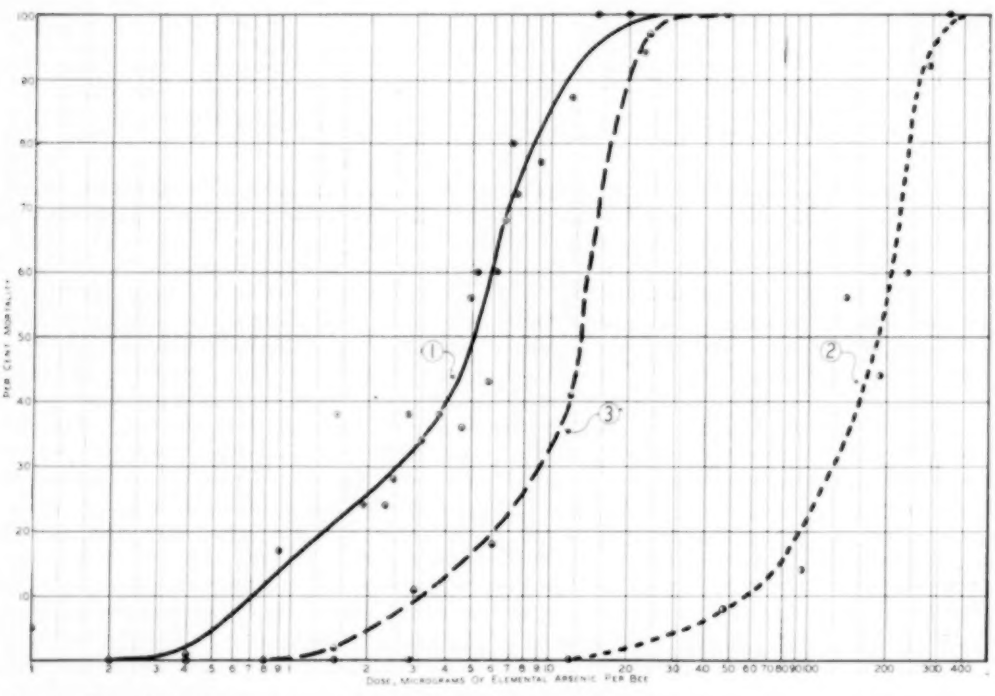

FIG. 2.—The relation between size of dose and the mortality of honeybees within a 3-day period, when the insecticides fed were three samples of acid lead arsenate, (1) of fine particle size, (2) of coarse particle size, and (3) of the ordinary unclassified commercial material.

figure 1. There is a striking difference in toxicity between the fine and the coarse material, the median lethal dose being about 5 micrograms of elemental arsenic for the fine and about 185 micrograms for the coarse, as compared with 13 micrograms for the commercial material. The similarity between the commercial material and the fine material is to be expected, since the former is composed mostly of particles of the order of 2 microns or less in diameter (Goodhue 1940).

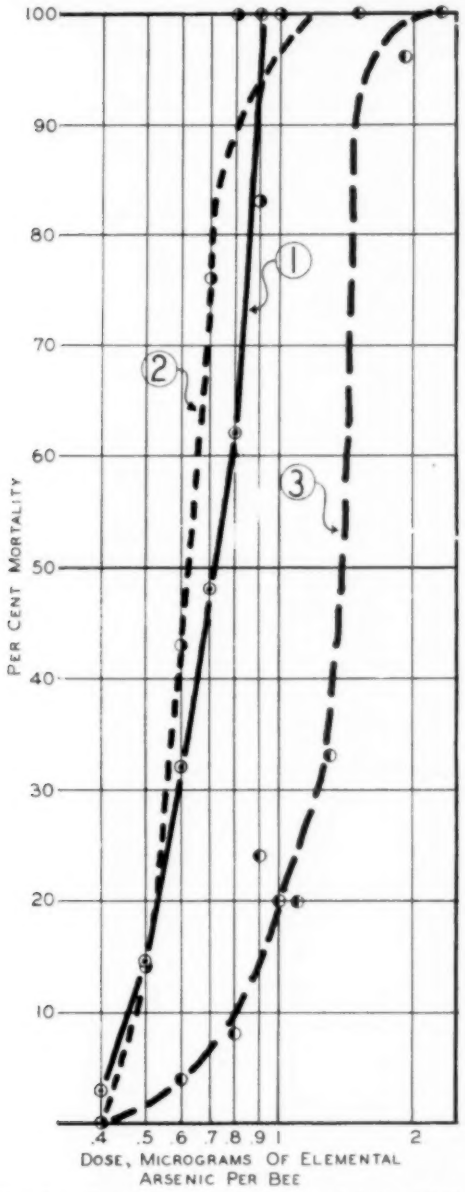

FIG. 3.—The relation between size of dose and the mortality of honeybees within a 3-day period, when the insecticides fed were three samples of calcium arsenate, (1) of fine particle size, (2) of medium particle size, and (3) of coarse particle size.

Calcium Arsenate.—The results for calcium arsenate are presented in the second section of table 4 and in figure 3. The toxicity of the fine and medium fractions

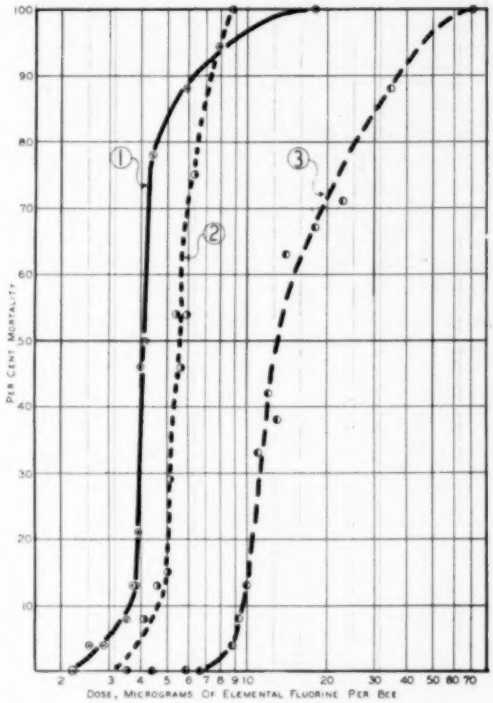

FIG. 4.—Relation between size of dose and mortality of honeybees within a 3-day period, when the insecticides fed were three samples of synthetic cryolite, (1) of fine particle size, (2) of medium particle size, and (3) of coarse particle size.

is almost the same, the median lethal dose being about 0.7 microgram of elemental arsenic. The coarse fraction is somewhat less toxic, the median lethal dose being about 1.3 micrograms. Thus, even the coarse material is considerably more toxic than any fraction of lead arsenate tried.

Phenothiazine.—The results from the tests on the three fractions of phenothiazine are given in the third section of table 4. There was practically no mortality from any dose except that of 141 micrograms. It is assumed, therefore, that some accidental factor was operating when this dose was administered and that the results are not reliable. From the other data it appears that phenothiazine, whether of fine, medium, or coarse particle size, and given in doses ranging from 35 to 560

micrograms, is virtually nontoxic to bees.

Cryolite.—The results of the tests on cryolite are given in the last section of table 4 and in figure 4. The fine and medium fractions are similar in toxicity and considerably more toxic than the coarse fraction. The median lethal doses for fine, medium, and coarse particles are approximately 4.2, 5.5, and 13.0 micrograms of elemental fluorine, respectively.

DISCUSSION.—*Arsenicals.* Much of the work reported in the literature on the effect of arsenicals has had to do with determination of the minimum lethal dose, but the various investigators have had little agreement as to the definition of "minimum." Price (1920) who was one of the first to make quantitative tests on this problem, used as a criterion of the toxicity of arsenic trioxide the length of time that the bee lived on a starvation diet after ingesting a measured quantity of the poison. But since he apparently kept no non-poisoned bees on starvation diet as checks, he could not be certain, when small doses were fed, whether death was due to the arsenicals or to starvation. McIndoo & Demuth (1926) also used the length of life of poisoned bees as a criterion of toxicity, but they used controls for comparison. They fed by mass feeding, lots of 100 to 500 bees, definite amounts of various arsenicals mixed in sugar candy or honey, and then kept the bees well supplied with non-poisoned candy or honey until they died. The lots were kept in cages at room temperature by a window. The dead bees were counted daily. Control lots were treated in the same way except that they were given no poison. Doses ranged from 0.1 to 0.8 microgram of elemental arsenic per bee, and the average longevity ranged from 8.3 to 0.15 days, as compared with 9.8 for the controls. The authors concluded that 0.5 microgram of elemental arsenic "is a conservative quantity to represent the minimum lethal dose per bee." When several lots of 100 bees each were fed approximately this dose of six arsenicals, their average longevity was as follows: Arsenic acid, 5.5 days; sodium arsenate, 5.6 days; paris green, 5.7 days; acid lead arsenate, 5.7 days; zinc arsenite, 6.2 days; and calcium arsenate, 6.9 days. No probable errors are given, but since observations were made only at 24-hour intervals, it is likely that the differences between the first four of these, at any rate, are not significant. It is interesting to note, however, that calcium arsenate is found to be less toxic than lead arsenate on the basis of equivalent amounts of metallic arsenic, quite the reverse of the results reported for the present investigation.

Borchert (1929), in tests with 21 commercial arsenicals and pure sodium arsenate, used as a criterion the percentage killed within 24 hours and defined as "minimum" the dose that would kill one-fourth to one-third of the test bees in this period. His results with the commercial preparations indicated that 1.2 micrograms of arsenious acid or 0.8 microgram of metallic arsenic is sufficient to kill an individual bee, but that with sodium arsenate the equivalent of 1.8 micrograms of metallic arsenic was required. Prell (1934) showed later, that by correcting an error in the calculations this latter figure for metallic arsenic should be 0.9 microgram. Himmer (1934) found the minimum lethal dose for each bee to be 0.2 to 0.3 microgram of arsenic trioxide or 0.11 to 0.14 microgram of metallic arsenic. He does not give the criterion used, but presumably it was the same as Borchert's. Böttcher (1939) in several papers quoted Himmer as having found 0.19 microgram of arsenic to be the minimum lethal dose, but this is presumably the dose that will kill 25 to 33 per cent of the test bees in 72 hours instead of 24, since Böttcher used the longer period in his own tests.

The extent to which the value obtained for the minimum lethal dose depends upon the criterion used may be illustrated from the data on acid lead arsenate given in table 2. If one defines this dose as that which kills 25 to 33 per cent in 24 hours, then it amounts to about 25 micrograms of arsenic per bee. If it is defined as the quantity that kills 25 to 33 per cent in 72 hours, then it amounts to about 10 micrograms. If it is defined as the quantity that reduces the average longevity to half that of the controls, then it amounts to about 3 micrograms. And if, as in the present paper, one uses a median lethal dose, defined as the dose which kills one-half the test animals in an arbitrarily chosen period—in this case 72 hours—then the dose is about 13 micrograms as interpolated from the curve in figure 1.

The experiments reported here also show a clear dependence of the toxicity of

arsenic for the honeybee upon the compound in which it occurs. Arsenic in the form of commercial calcium arsenate proved about 25 times as toxic to the bees as arsenic combined in the form of acid lead arsenate (Fig. 1). And even the coarse fraction of calcium arsenate was four times as toxic as the fine fraction of lead arsenate (Figs. 2 and 3). The reason for the greater toxicity of calcium arsenate is suggested by the researches of Swingle (1938) and of Hoskins & Harrison (1934). The former has shown that the formation of soluble arsenic from lead and calcium arsenate in the insect's gut is dependent largely on the hydrogen ion concentration found there, but that, whereas an acid condition is conducive to the dissolving of calcium arsenate, a basic condition is necessary to dissolve acid lead arsenate. When this is correlated with the discovery by Hoskins & Harrison that the contents of the gut of the bees are acid (ventriculus, pH 6.3), an explanation for the greater toxicity of calcium arsenate seems apparent. Much caution must be exercised, however, in drawing conclusions as to how much more toxic calcium arsenate is than lead arsenate, because it is rarely possible to obtain calcium arsenate in a chemically pure state, different samples varying both in their composition and in their solubility, and it is therefore difficult to get reproducible results.

Phenothiazine.—The only other experiments that appear to have been recorded on the effect of phenothiazine on honeybees are those of Marvin.[5] He fed bees a candy consisting of 1 gm. of phenothiazine, 1 gm. of bentonite, 0.5 cc. of fish oil, 87.1 gms. of granulated sugar, 562.6 gms. of powdered sugar, and 184.2 gms. of water, and found that they lived only about half as long as did bees fed plain sugar candy (3.89 as compared to 7.43 days). But he also found that bees fed phenothiazine lived longer than those fed lead arsenate, pyrethrum, derris, or cubé. They were outlived only by the checks and by those fed nicotine.

Cryolite and other fluorine compounds.—Many papers on the effect of cryolite and other fluorine compounds on various insects have been published in the last 15 years, but only a few of these consider their effect on honeybees. Borchert (1929) found that the minimum dose of sodium fluoride required to kill one-fourth to one-third of the test bees in 24 hours was 13 micrograms per bee, or 5.9 micrograms of elemental fluorine. Kunze (1929) found sodium fluoride to be fairly distasteful to bees but not enough so to prevent them from sucking it up when it was mixed with sugar; he also found this material to be decidedly toxic but did not determine the lethal dose.

Körting (1933), testing a number of fluorine compounds, including synthetic cryolite, found that the size of the lethal dose depends upon the compound in which the fluorine is incorporated. Stated in terms of median lethal dose, his figures are approximately as follows: For potassium fluosilicate, 5 micrograms of fluorine per bee; for sodium fluoride, barium fluosilicate, and cryolite, 6 to 7 micrograms; for sodium fluosilicate, 24 micrograms; and for calcium fluoride, over 54 micrograms. Whether or not his results agree with those of the writers is difficult to say, since he ascertained the number killed in 22 to 24 hours instead of 72 hours.

CONCLUSION.—So far as the original problem is concerned—namely, the finding of an insecticide that is deadly for codling moth larvae while being practically nontoxic for bees—it appears probable, from the results here recorded, that the requirements may be met to a fairly satisfactory degree by either fine or medium-sized particles of phenothiazine, and to a lesser degree by coarse particles of acid lead arsenate. Siegler & Goodhue (1939) found that under laboratory conditions fine and medium fractions of phenothiazine were highly toxic to the codling moth larvae, the percentage of clean apple plugs resulting after spraying being 86 and 90, respectively, and that coarse acid lead arsenate was fairly effective, giving 61 per cent of clean plugs.

Whether there are conditions prevailing in the field that will render the use of phenothiazine impracticable remains to be seen. If not, and if the material can be produced cheaply enough, its general use would seem to be a great boon to beekeepers. If it proves desirable to continue the use of lead arsenate, then it would seem advisable to try to find a means of producing larger particles and to test these under field conditions, since under laboratory

[5] Marvin, George E., P.W.A. codling moth project; effect of certain insecticides upon honeybees. Unpublished manuscript in files of Division of Bee Culture, Bureau of Entomology and Plant Quarantine. 1934.

conditions the use of coarse fractions appears both to increase the effectiveness of lead arsenate against the codling moth and to decrease its toxicity to bees.

SUMMARY.—Various insecticides that are used for the control of the codling moth have been used in toxicity tests against the honeybee, in the hope of finding one that is harmless to bees. Weighed amounts of acid lead arsenate, calcium arsenate, phenothiazine, and cryolite were finely suspended in measured volumes of 60 to 65 per cent sucrose sirup, and measured volumes of these suspensions were then fed to bees individually in a single dose by the capillary pipette method. After being fed, the bees were confined in cages, given an adequate supply of sugar sirup, and placed in an incubator at 83 to 85 degrees F. for 3 days, the number dead at the expiration of that time being used as a measure of toxicity.

When ordinary commercial insecticides were used, unclassified as to particle size, the calcium arsenate proved to be most toxic, practically as toxic as the soluble arsenic pentoxide, and lead arsenate much less toxic, the median lethal doses of the two being approximately 0.6 and 13.4 micrograms of elemental arsenic per bee, respectively. Phenothiazine was scarcely toxic at all, even in doses up to 570 micrograms per bee.

When materials of different particle size were used, the fine fractions were on the whole more toxic than the coarse. All sizes of calcium arsenate particles proved, however, to be more toxic than even the finest lead arsenate. Cryolite was fairly toxic, but phenothiazine, although somewhat inconsistent in its action, seemed to be virtually nontoxic in all dosages commonly used.

The median lethal doses of the arsenicals and of cryolite, in micrograms of active ingredient per bee, were as follows: Calcium arsenate (As), fine and medium 0.7, commercial 0.6, coarse 1.3; acid lead arsenate (As), fine 5.0, commercial 13, coarse 185; synthetic cryolite (F), fine 4.2, medium 5.5, coarse 13.0.

Caution is urged in accepting the median lethal dose for calcium arsenate as of equal value with the others, because this is not a chemically pure compound and different batches as manufactured vary considerably in composition.

From these laboratory experiments it appears that phenothiazine in fine or medium-sized particles and, to a lesser degree, coarse acid lead arsenate meet the requirements for a codling moth insecticide that is nonpoisonous to bees. The practicability of the use of phenothiazine under field conditions remains to be determined, and if field tests show the desirability of continuing with lead arsenate, the problem may be solved by the use of a coarser form of this material for the treatment of plants.—1-7-41.

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The Behavior of Young Bees in Confinement

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Until recently it has been accepted without question that colonies of bees discontinue brood-rearing in autumn and normally renew this activity under the stimulus of incoming nectar or pollen in spring. Under the assumption that such behavior of the bees is advantageous, the physiological and environmental factors involved have been determined so that colonies may be provided with conditions which will enable them to pass the winter without waste of vitality, and, when brood-rearing begins, be strong enough to increase the colony population properly. Recent discussions have questioned some of these basic assumptions, and it is now proposed that instead of helping the bees to conserve their vitality, they be placed under such conditions as to force them to rear brood during winter, in order that the workers which go into winter shall die out and be replaced by newly reared bees. Such rearing of brood in winter is admitted to require greater consumption of honey and pollen, but if it should prove to be possible, by the use of such methods, to obtain correspondingly stronger colonies at the time of harvest, the cost is considered justifiable.

If the new proposal is accepted, it becomes necessary to employ methods of wintering formerly considered undesirable, as the elimination of heavy insulation in cold climates and insuring that colonies have added amounts of pollen, or other protein food as a supplement or substitute, to support the rearing of brood at a time when pollen is not otherwise consumed and when it cannot be collected The new theory also seems to presuppose the use of upward ventilation of hives to permit the escape of moisture generated by excessive metabolic activity incident to brood-rearing, a method long recognized as essential when a hive is not adequately insulated but also known to be wasteful of heat generated by the bees, hence thought to be unnecessary and undesirable under the formerly accepted procedures.

In undertaking to consider the newer hypothesis fairly, one encounters difficulty, since neither the theory nor the accepted practice under the theory has been adequately stated. One looks in vain for scientific observations in support of the hypothesis. Under these conditions, it might be thought unnecessary to give it attention, but, since beekeepers are now urged to abandon practices which have given good results, it is desirable to investigate the soundness of such teachings. In terms of practical results, evidence seems to be at hand, for losses of colonies in the severe winter of 1939–40 were terrific. It is of course, not fair to attribute all the losses of last winter to the new teachings, for many beekeepers who lost bees were simply careless and found in the proposals rationalization of their own carelessness.

While some beekeepers have undertaken to follow the recommendations arising from the new theories, they have not been able to do so completely, because of the impossibility of adding to the pollen stores of a colony. If it is found not to be practicable to use all the methods necessitated by the new theory, then the plan will be judged by results obtained by those who have done their best to follow instructions. It, therefore, seems imperative that pertainent facts in the physiology and behavior of bees be mustered in an effort to explore the hypothesis.

The determination of the validity of the proposed new methods must depend on several important types of observations and discovery. There must be developed some means whereby, with reasonable expense and labor, a beekeeper may provide his colonies with additional pollen

or an adequate supplement or substitute. It must be demonstrated that when brood is reared during a period of confinement, colonies actually attain greater strength prior to the honeyflow than they do by methods formerly advocated. It must also be factually demonstrated that bees reared in confienment behave, and participate in the activities of the colony, normally, and it is the chief purpose of this paper to record observations on this essential aspect of the problem.

Colonies of bees of average size discontinue brood-rearing in autumn and, during the period of broodlessness, adult bees do not require pollen in their diet. The stimuli which bring about discontinuance of brood-rearing are not well understood. in contrast, the stimuli which cause bees to renew this activity during winter are well known. These are exposure to extreme cold, an accumulation of feces in the individual bees, or any other disturbance which will cause the bees of the cluster, especially those of the insulating zone, to generate heat by muscular activity sufficient to raise the temperature of the inner parts of the cluster to the brood-rearing point. These statements must be qualified by indicating that if a winter disturbance is of short duration, it may not cause brood-rearing to begin. The presence of eggs or pupae in cells within the cluster does not necessarily stimulate the bees to maintain a temperature normal to brood-rearing, whereas the presence of larvae does have this effect, if the bees are capable of it. Honey and pollen in combs do not stimulate brood-rearing, but, of course, both are required if brood-rearing occurs. If brood-rearing begins in winter, it is rarely discontinued during the winter or until the colony dies of dysentery or exhaustion. The use of all the pollen stores will, of course, force brood-rearing to cease, and this will also leave the colony in poor condition for brood-rearing later.

A word of elaboration seems necessary, regarding the fact that stores of honey and pollen do not stimulate brood-rearing in confinement, whereas incoming nectar or pollen serves as such a stimulus. The explanation is simple, for when the bees break cluster and engage in their first gathering of nectar or pollen, temperatures of all parts of the hive rise quickly, due to increased muscular activity, and egg-laying begins. Flights during winter for the voiding of feces rarely cause the same temperature conditions, partly because heat production is less but especially because the higher temperatures incident to flight are of short duration during winter. One experienced in observing temperature relations of a colony can determine from the temperatures alone whether or not new supplies are being collected.

In work conducted by the late George S. Demuth and the writer on the behavior and physiology of bees in winter, tests were made of all manner of methods which had been advocated for wintering in cold climates, great care being exercised to duplicate recommended conditions exactly. Obviously, in using some of these methods, the results were not all good, but it seemed essential that they be tried. In many instances protection was absent or scant and brood-rearing was instituted in such colonies, hence it was possible to make many observations on colonies which were forced to rear brood in confinement. Since, at the time of publication of the results, it was generally believed that winter should be a period of broodlessness, it seemed then unnecessary to publish results of all the experiments which induced brood-rearing in confinement. Now that the counter-theory of wintering is proposed, the results of observations then made on brood-rearing in confinement take on new interest.

In the autumn of 1912 a number of colonies of bees were placed in a constant-temperature room maintained like a bee cellar, the average temperature for the entire period being 42.67° F. Since in Philadelphia, where this work was done, the period of winter is short, it was desired to prolong confinement in the cellar to five months, so as to make the observations comparable to those in colder locations. Since it is the experience of beekeepers that confinement in a cellar in spring is more difficult than it is earlier, the colonies were put into winter confinement early. The colonies were placed in the constant-temperature room on October 3 and the activities of nine colonies thus treated may be indicated by what occurred in colony 1, wintered on ordinary honey stores with normal pollen supplies. Notes on this colony follow:

Oct. 3. Colony removed from the regular hive and combs containing some brood and the usual stores to a special hive, con-

taining six combs with honey and pollen. At the time of the transfer, flight had ceased for the day and the bees were left on their stand over night.

Oct. 4. Colony removed to constant-temperature room at 9 A.M. before flight occurred.

Oct. 5. During the day the colony was wired for thermocouples for winter temperature observations. The bees were as quiet as customary during this operation, and the disturbance by the operation was inconsequential. Since this same operation was later performed on many colonies it may be concluded that it does no harm.

Oct. 6–9. The colony had not entirely quieted down and excitement was increasing.

Oct. 10. Colony restless. Temperature in the part of the hive where the cluster had been formed reached 100° F. at intervals during the morning, a temperature not observed under any conditions other than those pertaining to this colony. Colony removed from constant-temperature room at noon and the bees flew freely until the outside temperature made further flight impossible.

Oct. 11. Colony returned to constant temperature room at 9 A.M.

Oct. 12. Colony rewired with thermocouples at 1:15 P.M. Bees quiet. At the time for return to the constant-temperature room, the hive was found to have lost 3 pounds, 1 1/4 ounces, since Oct. 3.

When this colony was removed from the constant-temperature room on Oct. 10, many dead bees were found on the bottom board, which should not occur in bees wintering well in a cellar, so that the loss of weight was the result of honey consumption at the prevailing high temperatures and of the death of bees. The eight other colonies similarly treated behaved in the same manner. Since these nine colonies were later exposed to different conditions, especially as to winter food, the final results differed, but, after their return to the room, all nine behaved in a manner which an experienced beekeeper would consider satisfactory.

Coincident with the work with these nine colonies, observations of another sort were made. It was desired to compare the winter behavior of young bees with that of bees of average age and of advanced age. To obtain a colony composed exclusively of young bees, the brood removed from the above nine colonies, which was mostly sealed, was placed in three hive bodies, taken into the laboratory and kept near a steam radiator to provide warmth necessary for the emergence of sealed brood. These bees were later given a queen in order that conditions might be considered normal, although the presence of absence of a queen was not found to affect the behavior of broodless bees in winter. The combs of brood were left in the laboratory for a week, during which time virtually all the sealed brood had emerged, and the number of bees which emerged was adequate to form a good colony for winter observations. Whenever the cover of the pile of hives was lifted to determine whether bees were emerging well, inevitably a bee or two would escape, and such bees flew to the window. From the first instance it was noted that escaping bees voided large amounts of feces on alighting on the window or before. Because of this observation, it seemed best not to put the newly formed colony into the constant temperature room at once, so it was taken outside to permit several days of flight. It was then placed in the constant-temperature room, on Oct. 23, wired at once and thereafter behaved normally. On removal to the outside, the bees voided large amounts of feces, although no brood was being reared and the bees were seemingly in good condition. Subsequent flights, while outdoors, were enough to prevent an accumulation of feces from the food currently being consumed.

Proper interpretation of these accessory observations leads to important conclusions. In the nine colonies from which brood was removed, there were, at the time of removal, many young bees which had not yet flown, although the weather prior to this manipulation was often suitable for flight. After these colonies were first placed in the room, the bees gradually attained the age when flight is desirable and finally the age at which flight is obligatory, and when this time arrived, they became abnormally agitated. Their activity not only was detrimental to themselves but it stirred up the bees of the entire colony to greatly increased activity, with the results noted in the abnormally high temperatures. Colonies in that and later years handled in exactly the same manner, but in which there had not recently been any brood, all behaved normally

when taken to the constant-temperature room, and as already stated, wiring for thermocouples is not detrimental. There seems no way to account for the abnormal condition of the nine colonies except by attributing it to the necessity of flight to recently emerged bees. In exactly the same manner, the spotting of the bees which emerged from frames of brood is explained. It is well known that during pupation, feces accumulate in the alimentary canals of bees, the waste arising from the high metabolic rate. It is then no exaggeration to state that on emergence honeybees have dysentery, from which they must be relieved within a few days. Young bees do not fly immediately on emergence; usually four to seven days pass before flight occurs, depending on weather conditions. Even in summer, if flight is prevented, young bees become agitated, and such agitation is especially marked in winter confinement.

During the long series of observations on behavior in winter, numerous observations were made which explain the connection between dysentery and winter brood-rearing. In all colonies, however good the stores, there is some accumulation of feces from the first day of confinement to the hive. As the period of confinement is prolonged, this accumulation becomes more marked, attested by higher and higher temperatures within the cluster. If the stores are of good quality, although the temperature slowly rises, it does not reach the temperature of brood-rearing during five months of cellar confinement, but if the stores are poor, brood-rearing may begin by the middle of December, or even earlier if the stores are exceptionally poor. The important point to remember is that all colonies show at least a slight rise in temperature as winter progresses, so this appears to be a normal expectancy.

If with this rise of cluster temperature there come other disturbing factors, brood-rearing occurs. Thus it was not possible to take a normal, queen-right colony into the constant-temperature room and wire it for thermocouples after about December 15, in any of the years of our work, without starting brood-rearing. Such facts are, of course, well known to all observant beekeepers, and were supported by several years of observations in the work which Demuth and the writer did. This type of observation is supported by the fact that damage is often done to colonies of bees by packing them some time after flight has ceased, and it is well known that colonies packed too late rarely survive.

The behavior of bees which have some accumulation of feces seems not to have been adequately described, and since this was repeatedly observed in our work, a description now seems desirable. A quiet normal winter cluster consists of an inner heat-producing zone and an almost immobile outer insulation zone. As an accumulation of feces occurs, the bees of the insulation zone no longer remain quiet, although they move only short distances and do not engage in anything comparable to the muscular activities of the heat producing zone. Since any muscular activity causes the generation of heat, even the slight unrest of the bees of the insulating zone causes the temperature of that part of the cluster to rise, and this rise in temperature naturally increases as unrest due to accumulation of feces increases. In a colony with dysentery, characterized by spotting of the hive, the temperature of the entire cluster is at a brood-rearing leve, and under such conditions the bees wear our rapidly. This fully accounts for the fact that a colony with dysentery either dies or shows spring dwindling, which is merely an indication of poor wintering.

In addition to the general lack of recorded observations in support of the new hypothesis on wintering, three specific obstacles to its acceptance were stated earlier. These are indicated by the following statements of the existing situation with respect to each one: No practicable method is reported whereby additional stores of pollen or of a pollen substitute or supplement may be given to colonies. Colonies which begin brood-rearing early, not as a result of the stimulus of incoming nectar or pollen, usually attain full strength late. Young bees require flight shortly after emergence, and if prevented from flight by confinement, they not only become exceptionally active but they incite hive mates to great activity. Until these three difficulties are overcome, acceptance of the new theory is not justified.—1-7-41.

Vitamin Content of Bee Foods. III: Vitamin A and Riboflavin Content of Bee Bread*

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In two previous papers (Haydak & Palmer 1938, 1940), the authors presented the results of experiments on the vitamin E and B_1 content of bee bread. The search through the literature has not revealed any work on vitamin A or riboflavin content of bee bread or pollen.

Vitamin A. Method.—Female rats were placed on the Steenbock (1903) low A diet during the last stage of pregnancy and the mothers and young maintained on this diet until the young were weaned at three weeks of age when their average weight was about 32 gms. They were then placed on the basal A-free diet consisting of purified casein 18, Hawk-Oser salt mixture 4, *Crisco* 5, dried yeast (irradiated for 20 minutes) 8, dextrin 65. The rats were depleted (showed xerophthalmia and a decline in weight) in about 35 days. The average weight at that time was 86 gms. The rats were divided into four groups, each animal being kept in a separate cage. Each group received a different daily supplement, namely at the rate of three I.U. and six I.U. of vitamin A per rat as U.S.P. Reference Oil; also, 0.5 gm. and 1.0 gm. of bee bread per rat. Actually the supplements were given twice a week. The diluted Reference Oil was added by pipette to a small amount of food and mixed in a mortar. The bee bread was suspended in a little water and then thoroughly mixed with the basal ration. This deviation from the standard procedure has been made on the basis of Coward's (1938) findings.

Table 1.—Vitamin A activity of bee bread.

Supplement	Rats Fed Daily	No. of Rats	Average Weekly Gain per Rat—Grams
Reference cod liver oil	3 I.U.	3	8
Reference cod liver oil	6 I.U.	3	14
Bee bread	0.5 gm.	4	9
Bee bread	1.0 gm.	5	12

Results.—The results of the experiment are presented in table 1.

It is obvious that the vitamin A activity of bee bread is about equal to that of 6 I.U. per gram of fresh and 8.4 I.U. per gram of dry matter (moisture content of bee bread is 29 per cent).

Riboflavin. Method.—A somewhat modified Supplee *et al.* (1939) technique was used in the experiment. The rats when 16 days old were placed with their mothers on the following ration: purified casein 35, sucrose 47, *Crisco* 5, Hawk-Oser salt mixture 4, butter-fat 9. They were weaned when 21 days old and continued on this ration until a constant or declining weight was established. Then 200 mgms. of *Labco Rice Polish Concentrate* was fed daily to the rats thus supplying deficient factors except riboflavin. The growth was resumed for a short time (2 to 4 weeks) and after a constant weight or a gain of about 1 to 2 gms. a week was established, the rats received their daily supplement: 5γ or 10γ of synthetic d-riboflavin, 0.25 gm., 0.5 gm. or 1.0 gm. of bee bread (one and one-half years old). The riboflavin and the bee bread were given daily added to aqueous suspension of the rice polish concentrate in a separate dish. These were usually eagerly consumed by the rats. Three rats did not receive any supplement and served as negative controls. The average weight of the rats at the start of the test period was 53 gms. The test lasted four weeks.

Results.—The results of the experiment are presented in table 2.

Table 2.—Riboflavin content of bee bread.

Supplement	Rats Fed Daily	No. of Rats	Average Weekly Gain per Rat—Grams
None	0.0	3	4.0
d-riboflavin	5γ	3	10.0
d-riboflavin	10γ	3	15.0
Bee bread	0.25 gm.	2	6.0
Bee bread	0.50 gm.	6	15.0
Bee bread	1.00 gm.	3	23.0

From the results of this assay, one can conclude that there are 20γ of riboflavin per gram of fresh and 28γ of riboflavin per gram of dry matter of bee bread.

* Paper No. 1872 Scientific Journal Series Article, Minnesota Agricultural Experiment Station, St. Paul.

SUMMARY.—A biological assay has been described in which laboratory rats were fed various levels of bee bread in order to evaluate the vitamin A activity and riboflavin content of this food of honey bees. It has been found that the vitamin A activity of bee bread is equal to that of 6 I.U. and 8.4 I.U. for gram of fresh and dry matter respectively. The riboflavin content was equal to 20γ per one gram of fresh and 28γ per gram of dry matter of bee bread.—1-7-41.

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Biological Observations on *Xylosandrus germanus* (Bldfd.)

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Felt (1932) reported *Xylosandrus germanus* (Bldfd.) (*Xyleborus germanus* Bldfd.) as a pest new to this country, having bred hundreds of adults from greenhouse-grown grape stems received from Oyster Bay, Long Island. Heretofore, according to Felt, this species has been reported only from Japan, Korea, and Formosa, and known to attack *Benzoin thunbergii*, *Carpinus laxiflora*, and *Styrax japonicum*. Clausen (1931) has also recorded mulberry as a host in Japan. However, there is little published information relative to its biology. The species has been found to breed in elm in the United States and is suspected of being an inoculative agent of the Dutch elm disease fungus, *Ceratostomella ulmi* (Schwarz) Buisman. Because of this a study of its life history and habits was undertaken at the Morristown, N. J., laboratory of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

METHODS OF STUDY.—To supplement field observations on the life history and to obtain data on the span of emergence, field-infested material was isolated in different kinds of rearing containers at the laboratory. The most efficient type of container was a hollow steel cylinder measuring about 32 inches in height and 22 inches in diameter. One end of the cylinder was sunk a few inches into the ground, whereas the other end was covered with a piece of rubberized fabric securely tied in position. Four specially devised nozzles were placed approximately equidistant about the upper portion of the cylinder. The distal end of each of the nozzles was wrapped with enough splicing tape to make it fit tightly into the neck of a 4-ounce glass bottle. Emerging adults were attracted by light into the bottles, which could be readily emptied or replaced. Occasionally the infested material placed within the cylinder was wet with water.

Detailed studies, with special reference to the duration of stages, were facilitated by isolating specimens in petri plates containing two pieces of moist filter paper. A few drops of water were added each day by means of an eye dropper.

LOCALITY AND FOOD-PLANT RECORDS.—This ambrosia beetle has been reared or found in elm material in the following states and counties: New York (Nassau, Westchester, and Rockland), New Jersey (Bergen, Essex, Morris, Union, and Middlesex), West Virginia (Cabell), and Ohio (Lawrence). In New Jersey it has also been bred from oak, red maple, beech, and hickory, and observed to attack poison ivy.

CHARACTER AND EXTENT OF INJURY.—Adults of *Xylosandrus germanus* have

* The author is indebted to A. E. Lantz of the Morristown, N. J., laboratory of the Bureau of Entomology and Plant Quarantine, for making the photographs, and to R. R. Whitten, of the same laboratory, for making the moisture determinations.

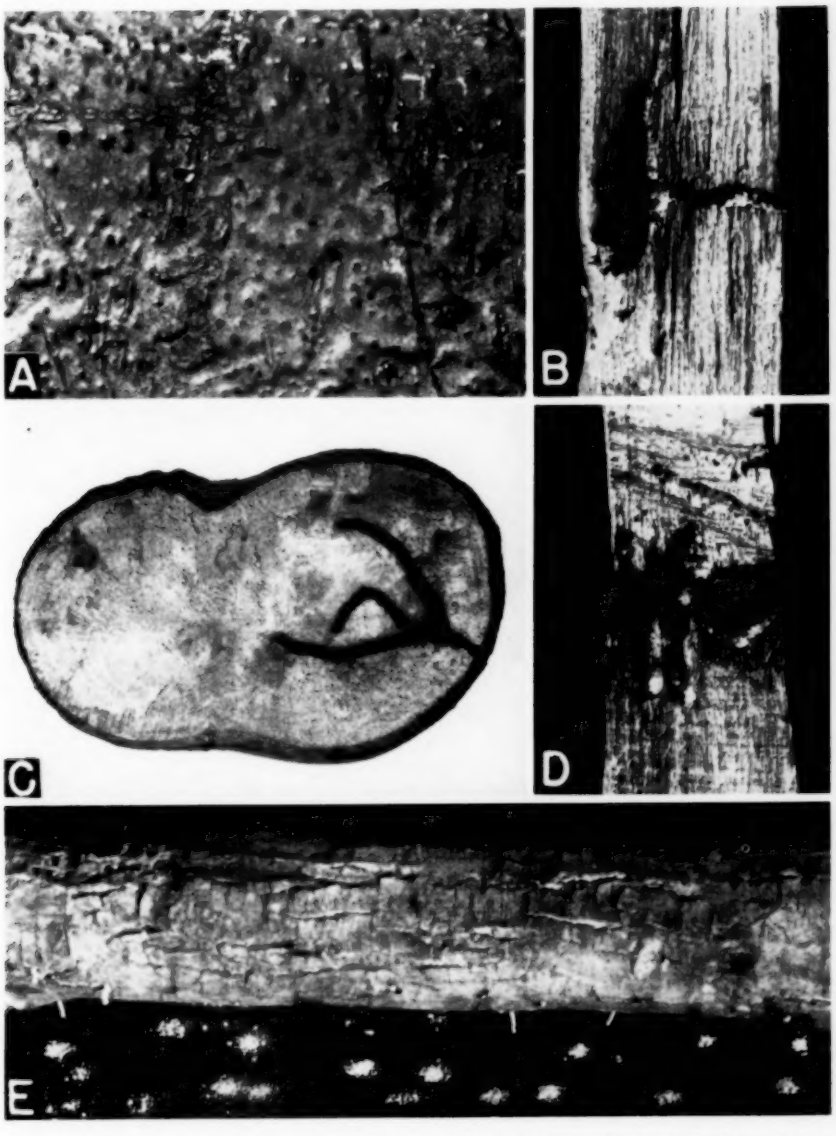

FIG. 1.—*Xylosandrus germanus* (Bldfd.): A, Entrance and exit holes in elm bark (×2.5); B, longitudinal section of elm root showing brood burrow (×4); C, transverse section of elm root showing brood burrow (×1.8); D, longitudinal section of red maple branch showing brood burrow (×4); E, cylindrical rods of borings and boring dust protruding from brood burrows in elm root (×0.9).

been observed to attack and sometimes reproduce in several types of host-plant material, such as recently felled, dead, and fire-scarred trees, chemically treated trees and logs, wind-broken branches, as well as freshly cut and old logs and stumps. The heaviest infestations seen in the field have been in elm branches partially submerged in streams and in the roots of old elm stumps located in moist situations. Although this species prefers to attack unhealthy or weakened trees, two instances of attack in apparently healthy trees have been noted. In the first case, reproduction was successful and many adults issued from four suppressed red maple trees ranging from 2 to 3 inches in diameter which, however, were in good foliage. In the second case, an adult which had contacted the xylem of a healthy elm tree, 4 inches in diameter and with good foliage, was captured in an entrance hole.

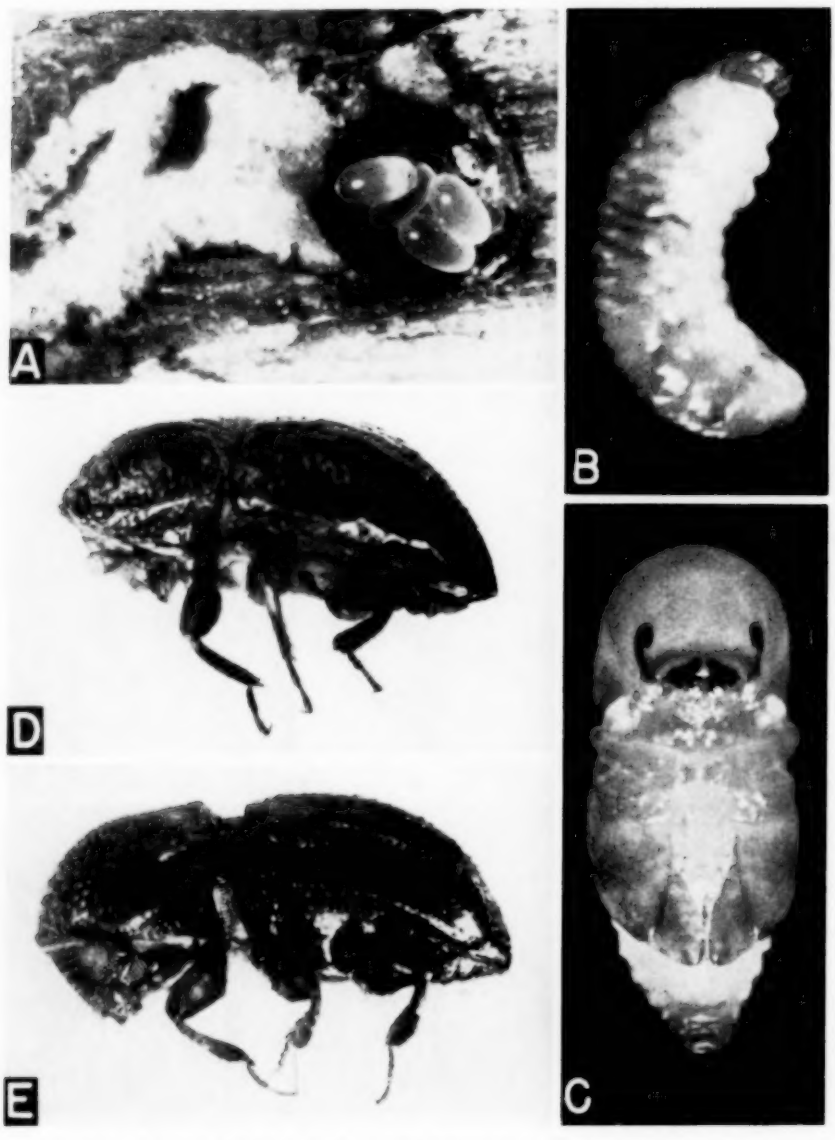

FIG. 2.—*Xylosandrus germanus* (Bldfd.): A, Eggs and ambrosia in brood burrow (×25); B, larva (×44); C, female pupa (×44.4); D, male adult (×63); E, female adult (×48.7).

Attack in both instances occurred in a locality where heavy infestations were present in nearby elm stumps.

Indications of the presence of this species in its host plants are the "shot holes," or entrances to the brood burrows, which are approximately 1 millimeter in diameter (Fig. 1, A), the fine borings around the entrance holes or on the bark or soil below, and the cylindrical rods of borings emanating from the entrance channels of the brood burrows (Fig. 1, E). The irregularly formed brood burrows are made in the wood, both with and across the grain, and the wood around the burrows is stained blue or black (Fig. 1, B, C, and D). During the construction of these burrows the females sometimes penetrate the wood to a depth of approximately an inch.

LIFE HISTORY AND HABITS.—Adult females of *Xylosandrus germanus* (Fig. 2, E) were observed flying and entering suitable breeding material on May 10, 1939, at several New Jersey localities. Since most of the attacks occurred in the roots of elm stumps previously treated with copper

sulfate, a number of these infested roots were severed and isolated in drums in the laboratory yard for rearing and study. Here, under moist conditions, the beetles produced characteristic cylindrical rods of borings. These protruded from the entrance holes and in 24 hours ranged in length from a few to 14 millimeters. Later, undisturbed borings attained a length of 75 millimeters. Although most of the entrances and galleries made in the spring of the year are in previously uninfested elm roots, some are formed beside old galleries in roots containing over-wintering adults of the previous year.

Late in May the branches of the irregularly formed galleries made in the wood range from a few to 18 millimeters in length, and each one may be lined with white hoarfrost-like ambrosia. Within those branches which serve as brood burrows the eggs are laid loosely together in small groups (Fig. 2, A). The eggs, which are ellipsoidal in shape and about 0.67 millimeter long and 0.38 millimeter in greatest width, are white, translucent, shiny, and soft. A number of egg-laying females were dissected and in none was more than one apparently mature egg found. Individual females oviposit over a period of about 3 weeks, and additional eggs mature during this time. As a consequence, it is not unusual to find all stages of this insect living together within a single burrow. The average duration of the egg stage for 140 eggs of unknown age kept in petri plates in an outdoor insectary was about 4 days (minimum 1, maximum 9), and the number of eggs laid per female, as determined by counting all the progeny present in a given brood burrow at the time of examination, ranged from 2 to 54.

Ordinarily the eggs are deposited in the distal parts of the ramifying channels of the brood burrow, where the ambrosial lining is from 0.15 to 0.45 mm. in thickness. A microscopic examination of the fungous growth found in the galleries of *Xylosandrus germanus* revealed that it belongs to type one of Hubbard's (1897) grouping, that is, to the erect or stylate forms (conidia bearing) found among those species of ambrosia beetles whose larvae live free in the galleries. The larvae, of course, feed upon the fungous growth, and as they approach maturity there seems to be a breaking down of the ambrosia into a substance resembling slushy snow. Later, when beetle emergence is completed and when the burrows become drier, only a black stain remains in the wood, giving the burrows the appearance of having been seared with a red-hot iron.

Recently-hatched larvae are elongate and rather flat, but as growth takes place they become robust and slightly curved (Fig. 2, B). They move slowly in an undulating fashion, seemingly setting the mandibles in the wood and pulling the body forward with the aid of muscular movements. Pupation occurs after a prepupal period of 2 or 3 days. Newly transformed pupae are white, and 12 females averaged 2.53 mm. in length and 1.09 mm. in greatest width, whereas 4 males averaged 1.78 mm. in length and 0.95 mm. in greatest width. Within 2 days after pupation color changes may be observed in the eyes, which several days later become brown (Fig. 2, C). A day or so preceding molting the mandibles are reddish-brown and the hind wings bluish. Sixty-one white female pupae selected at random spent an average of 7.34 days (minimum 3, maximum 10) in this stage under outdoor conditions.

General adults assume normal coloration 5 or 6 days after emergence. The longevity of 22 female adults confined in petri plates averaged about 27 days (minimum 3, maximum 40 days). Most of the foregoing observations were made on female specimens because of their abundance in all rearings. The examination of a large number of brood burrows revealed that one male in a burrow was the usual occurrence, although occasionally two were found (Fig. 2, D). The males bear rudimentary hind wings and therefore do not fly. This being the case, it is presumed that the females are fertilized in old brood burrows prior to leaving them to form new burrows elsewhere.

Under field conditions in New Jersey all stages of *Xylosandrus germanus* are present in brood burrows from June to September. Elm material in suitable condition for breeding sometimes enables this beetle to become exceptionally abundant locally. For example, a heavily infested elm branch having 9 square feet of bark surface, and found in May partially submerged in a river, produced, according to rearing records kept for the next 3 months, approximately 15,000 female adults. Although all stages are found in the field in September, most of the insects are adults,

and practically all are females. Many of the females pass the winter in the burrows in which they have developed from pupae. Some, however, apparently join the females of other galleries, for elm material examined in November contained from 15 to 200 huddled together in irregular chambers in the wood.

Attempts to infest different types of elm material with this species artificially met with little or no success. Recently infested material collected in the field in May and subsequently kept moist in rearing containers, on the other hand, produced large numbers of adults. At first it was suspected that moisture might be the factor limiting successful development. To test this hypothesis a number of moisture determinations were made. Ten increment cores of an average length of about 28 millimeters, exclusive of bark, were removed from a large root or log selected at random from each of four rearing containers with naturally infested material and from five containers with artificially infested material. The total moist weight of each lot of 10 cores was determined immediately after collection. These samples were then dried in an electric oven at 102° C. until their weight became constant. The percentage of moisture was computed on the basis of moist weight. Samples of naturally infested material showed rather uniform percentages of 51, 52, 52 and 53, respectively, whereas those of artificially infested material showed percentages of 36, 36, 51, 53, and 72. Since two of the moisture determinations fall within the range obtained for naturally infested material, however, it seems likely that moisture is not the only factor necessary to make a given host suitable for the multiplication of the species. The fact that heavily infested material found in the field often has a sour or fermented odor suggests that perhaps the wood must be in a certain condition of fermentation.

Since artificial rearings were largely unproductive, studies on the number of generations likely to be produced in a given year, as determined by this method, were impossible. Nevertheless, some data were obtained on this subject through the rearing of field-infested material. A number of isolations of roots recently attacked by *Xylosandrus germanus* yielded new adults 4 or 5 weeks later, indicating that the life cycle could be completed in that time. When the total issuance of approximately 30,000 individuals obtained by rearing infested material collected in the field from May to July was plotted by weeks, there appeared two peaks, indicating as many generations. The first peak was definite and occurred during the first 2 weeks of July, while the second, which was small, occurred during the first 2 weeks of August. The size of the latter peak may be explained by the fact that only a few field collections were made late in June and in July and, moreover, reattack in the rearing containers holding the May-collected wood was light. These data indicate that *X. germanus* has two generations a year in New Jersey; but since all stages are present in the field from June to September, inclusive, under favorable conditions a third generation might be completed.

Some of the species commonly found in elm wood material similar to that infested by *Xylosandrus germanus* are as follows: *Xyleborus saxeseni* (Ratz.), *X. affinis* Eichh., *Pterocyclon mali* Fitch, *Soclytus multistriatus* (Marsh.), *Hylurgopinus rufipes* (Eich.), *Saperda tridentata* Oliv., and *Synchroa punctata* Newm.

SUMMARY.—*Xylosandrus germanus*, an introduced oriental ambrosia bettle now established in the United States, has been reared from a number of woody plants. Ordinarily the species attacks stumps, logs, wind-broken branches, and moribund trees in this country. Female adults form irregular brood burrows in suitable host material and the wood about the burrows is stained blue or black. The larvae feed on the ambrosia in the burrow, and it is not unusual to find all stages of the species living together within a single burrow. Issuance of adults obtained by rearing field-infested material showed that the life cycle could be completed in 4 or 5 weeks and that two generations, possibly three, occur yearly in New Jersey.—10-19-40.

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Biological Notes on Two Species of *Melanophila*[1]

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Recent work by the Bureau of Entomology and Plant Quarantine has shed considerable light on the hitherto little known biologies of two species of Buprestidae, the California flatheaded borer, *Melanophila californica* Van Dyke, and the pine flatheaded borer, *Melanophila gentilis* Leconte. References to these species by Burke (1917, 1919), De Leon (1935), Hopkins (1899), Keen (1928, 1938), and others have been brief, observational notes, in many cases dealing chiefly with the host species. There has been an implication of general similarity of habits of the two species. Recent studies, initiated in 1936 by Salman & Bongberg, have shown that there are certain strikingly dissimilar features of habits and development. The following discussion is intended to apply to these two flathead borers only when found in ponderosa pine and Jeffrey pine in northeastern California.

Similarities in habits and development are found at the start and end of the life cycle. Eggs are laid in bark crevices of the host material, and newly hatched larvae mine through the bark to the region of the cambium. Emerging adults have overwintered as prepupae in bark cells. Seasonal cycles of pupation and emergence during the spring and summer are parallel. Adult habits of spasmodic flying, feeding on needles of the host species before attaining sexual maturity, and mating and ovipositing on warm, sunny days are common to both species. The necessity of adult feeding is a phenomenon of considerable interest.[3]

The striking dissimilarities occur within the developmental period between the egg and the prepupal stages. With *Melanophila gentilis* this period is very brief, while with *M. californica* at least a year is required.

Specific Larval Habits in Relation to Host Condition.—The larval development of the pine flatheaded borer, *Melanophila gentilis*, is rapid in its entirety, and is associated throughout with dying and dead host material. Slash and windfalls are the chief sources of host material in which broods of this species develop. A few records show that brood may develop in standing host material which has been injured in some manner, as, for example, by fire. Larval broods which become established during the summer mine in the cambium region. Young larvae can be detected by the line-like galleries visible on the inner surface of the phloem when the bark and wood are separated (Fig. 1).

Fig. 1.—Galleries of small larvae of *Melanophila gentilis* in inner bark of ponderosa pine.

These small galleries can also be traced on the wood surface as the result of clinging particles of frass, *but there is no mechanical injury to the wood itself*. From short galleries of this nature the larvae feed outward through the phloem, developing rapidly and forming typical flathead galleries (Fig. 2).

The larval development of the California flatheaded borer, *Melanophila californica*, is distinguished by two phases. The first phase, which marks the development of this species as distinct from that of *M. gentilis*, is one of slow growth in *living* host material, and may extend over a period as

[1] Paper read at the June 1939 meetings of the American Association for the Advancement of Science at Stanford University, Calif.

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[3] Recorded also for *Buprestis apricans* Herbst by J. A. Beal (U. S. Dept. Agr. Circ. 226, July 1932).

long as 4 years. It is strongly indicated that at least a year in this *incipient* stage is requisite to further development of broods. Eggs may be laid on such materials as slash and windfalls, but broods do not become established. An established brood is considered to be one in which the

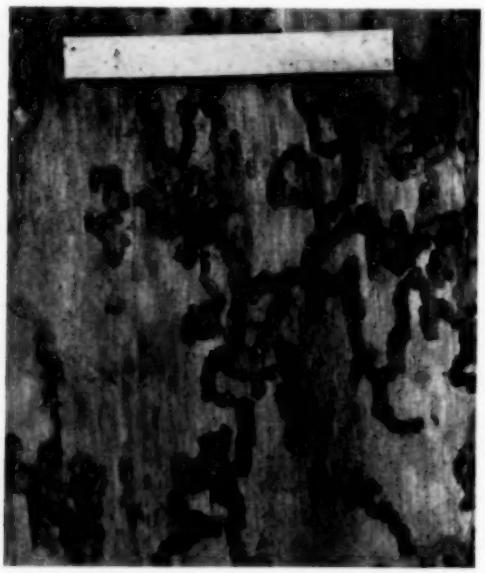

FIG. 2.—Typical galleries of large larvae of *Melanophila* sp. in inner bark of Jeffrey pine.

majority of individuals successfully overwinter. The term *incipient* has been used to designate both the small larvae and the galleries with which they are associated in living host material. As opposed to *M. gentilis* the larvae of *M. californica* injure both phloem and wood. During the period in which the host material remains alive the injury caused by these small larvae is healed over. This results in a twisting, ridgelike deformation on the wood surface with a counterpart in the phloem (Fig. 3). To date it has not been found possible to separate the larvae of the two species on a morphological basis. Rearing of adults from host material separated on the basis of appearance of larval galleries, however, has shown that it is possible to distinguish the work of these two species in the field.

As the result of subsequent tree growth the galleries of *Melanophila californica* become covered by successive annual rings. Thus, a permanent record of incipient attacks, frequently occurring successively over a period of years, is present. By examination of the number of growth rings overlying the point of origin of a gallery which is associated with a living larva it has been shown that a larva may remain in the incipient stage for as long as 4 years. Although broods of this species probably need at least a year in this incipient stage before developing further, the occurrence of that stage does not necessarily predicate a successful attack. The formation of these galleries must be considered a sign of resistance on the part of the tree.

The writer is indebted to Dr. F. C. Craighead for the following note on healed-over galleries:

"Although these so called 'incipient attacks' are rarely referred to in the literature with any degree of definiteness by the use of a special descriptive term, this feature is well known among entomologists as characteristic of the work of many buprestids attacking living trees, such as *Chrysobothris tranquebarica* in casuarina in Florida, *C. femorata* in hardwoods and fruit trees, *Agrilus anxius* in poplars and birch, and *A. bilineatus* in oaks and chestnut. It is also characteristic of some cerambycids, as *Glycobius speciosus* in sugar maple, *Goes* spp. in oak, and *Tetropium abietis* in fir. In the previous literature these early galleries have been considered unsuccessful attacks, the result of the inability of the larvae to overcome the resistance of the tree, *i.e.* an expression of the degree of vigor of the tree rather than

FIG. 3.—Healed-over incipient gallery of *Melanophila californica* in wood of ponderosa pine. Pointer indicates where mine started.

a requisite of the insect development."

It should be noted in particular that, while healed-over galleries have been mentioned in the literature, this is the first instance, to the writer's knowledge, in which a healed-over gallery has been shown to be an integral result of a part of the normal, successful development of an insect.

The second phase of larval development of *Melanophila californica* is a period of rapid growth, the initiation of which is associated with the death of the tree. This development corresponds to that of *M. gentilis* with the formation of typical flathead galleries in the phloem. The host material, which at this stage may be standing trees, slash, or windfalls, may be in a dying or dead condition similar to the host material of *M. gentilis* during the latter's entire period of larval development. It is important to note that for *M. californica*, regardless of the nature of the host material in which this advance stage of development is found, all such broods have developed from larvae that have probably spent at least a year in the incipient stage in living host material.

In the more vigorous trees incipient attacks are generally relatively unsuccessful, and successively originating broods die after an indeterminate period of development. In less vigorous host trees more abundant broods of mixed-age incipient larvae are commonly found. The second phase of larval development, which may start coincident with the attack of other insect species, or as the result of other environmental disturbances in standing trees, generally takes the same course when the death of the host results from logging or windfall. Hence it is frequently found that adults of both species will emerge during one season from a single piece of host material. The brood of *Melanophila californica* originated in eggs laid on living host material, ordinarily at least a year prior to death, while the brood of *M. gentilis* originated in eggs deposited during the dying period of the host.

FIXED AND VARIABLE LIFE CYCLES.—The pine flatheaded borer, *Melanophila gentilis*, has a 1-year life cycle while the California flatheaded borer has a life cycle varying from 2 to 5 years. Field and insectary studies have shown that *M. gentilis* attacks its host material in the summer of one year to emerge the following summer. *M. californica* usually requires the same period of development *after* entering the second phase of larval life. As previously mentioned, the larvae ordinarily do not enter this phase in northeastern California until they have spent at least 1 and frequently as long as 4 years in the first, or incipient, phase. Incipient larvae are generally present in a tree in inverse relationship of abundance to age, ranging from a few larvae 4 years old to a preponderance of 1-year-old larvae. Thus the emerging adults of *M. californica* may be of mixed age, and the length of the life cycle may have a minimum of 2 years. Field studies on slash and trap trees and insectary studies on forced attacks indicate that a 1-year life cycle ordinarily does not occur with the California flatheaded borer.—11-12-40.

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The European corn borer quarantine of the State of South Carolina as reissued on October 31, 1940, adds to the quarantined territory the States of Maryland, Virginia, and Wisconsin. Contrary to the current quarantines of many states, this order continues to maintain inspection requirements of oat and rye straw, and of cosmos, zinnia, and hollyhock.

California's intrastate quarantine pertaining to the peach mosaic disease was modified on November 12, 1940, to reduce the areas under regulation by eliminating the modified quarantine areas in the Counties of Los Angeles, Orange, and Imperial. lightly infected areas in these counties remaining unchanged. All restrictions were removed from nine townships in San Bernardino County.

Western Hemlock Sawfly, *Neodiprion tsugae* Middleton, and Its Parasites in Oregon

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An extensive outbreak of the western hemlock sawfly, *Neodiprion tsugae* Middleton, occurred on western hemlock, *Tsuga heterophylla* (Raf.) Sargent, near Sweet Home, Oregon, in the years 1933 to 1936. During the course of the infestation observations were made on the life history and habits of the sawfly in Oregon. The effects of the defoliation upon the host tree, which is an important lumber- and pulp-producing species in the Pacific Coast region, were determined. Observations were made on the life histories and habits of the many parasites that were reared from cocoons of *N. tsugae*.

Neodiprion tsugae is comparatively new in entomological literature. The adults were described by Middleton (1933) from material taken at Carroll Inlet, Alaska, and from the Queen Charlotte Islands, B. C. Additional specimens were noted from Astoria and Neah-Ka-Nie in Oregon and from Ketchikan, Alaska. Hopping & Leach (1936) reported that an outbreak of this sawfly killed many western hemlocks on the Queen Charlotte Islands during the period 1931 to 1933. From material collected during that outbreak these authors worked out the life history and habits at Vancouver, B. C., and described the egg, five larval instars, and the cocoon.

Distribution and Hosts.—A few additional records on the distribution of *Neodiprion tsugae* have since been made. On August 23, 1930, one female was reared in association with *Peronea variana* (Fern) on western hemlock at Sappho, Wash. Another female was reared on October 15, 1932, in association with *Ellopia fiscellaria* var. *lugubrosa* (Hulst) on western hemlock at Montesano, Wash. On June 27, 1937, several larvae were beaten from western hemlock foliage near Fairfax, Wash. From these larvae three female adults were reared during September of the same year. These records, together with those previously reported, indicate that the sawfly is probably present throughout the coastal portion of the western hemlock range, which extends from central California to Alaska.

History of Outbreak.—In August, 1934, extensive defoliation of western hemlock in Linn County, Oregon, was reported by the State Forester. An examination of the area was made by J. A. Beal, of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture, who found that heavy defoliation extended over approximately 10,000 acres and light infestation was present on about 50,000 acres in addition. The outbreak was localized between the Middle Fork of the Santiam River and Crabtree Creek in the vicinity of Sweet Home. The elevation of the area where infestation occurred ranges from about 2,000 to 4,000 feet. The predominating timber type is Douglas fir, *Pseudotsuga taxifolia* (Lamb.) Britt., and western hemlock in mixture. In places where the outbreak reached its upper altitudinal limits, the timber type is predominantly mountain hemlock, *Tsuga mertensiana* (Bong.) Sargent.

Evidences of sawfly feeding were seen in 1933 by members of the Linn County Forest Fire Patrol Association. Other than this, nothing is known concerning the early stages of the outbreak. It is certain, however, that the peak was reached in 1934. During the summer of that year many trees were almost completely defoliated, especially in sheltered basins and pockets of timber where hemlock made up a large proportion of the stand. In these situations all the old needles and most of the new ones were eaten by the sawfly larvae. Understory trees were practically stripped of their foliage.

In 1935 there was very little feeding within the area where defoliation had been heavy the preceding year, but in a fringe from one-fourth to one-half mile wide surrounding that area there was moderately heavy defoliation. Larvae were also found feeding upon mountain hemlock to a limited extent, but their development on that host was not studied. In 1936 no appreciable defoliation occurred, although in the fall newly formed cocoons were abundant enough so that a man could col-

lect between 1,000 and 1,500 in 8 hours. No observations were made in 1937.

No trees are known to have died solely as a result of the sawfly defoliation. It is true that a few trees did die during the course of the infestation, but all that were examined were found to be infected with a root rot, *Polyporus dryadeus* Fr., which greatly weakened the trees and seemed to be the primary cause of their death. Several partially defoliated hemlocks were noted in 1936 as being attacked by an ambrosia beetle, *Platypus wilsoni* Sw. In each case root rot had killed the cambium near the beetle galleries. Presumably, the defoliation of these trees also contributed toward weakening them to the point where they were subject to ambrosia beetle attacks. Potentially, *Neodiprion tsugae* is an important pest should it occur in association with a defoliator that prefers new foliage.

LIFE HISTORY AND HABITS.—The life cycle was worked out by rearing larvae under laboratory conditions and by supplementing this with field observations.

There is one generation a year in Oregon. At Sweet Home the egg-laying period began about the middle of August and continued until about the end of September. The eggs were deposited in slits in the edges of the hemlock needles of the current year's growth only. In practically all cases there was one egg to a needle and usually this was placed between the middle and the tip of the needle. A few needles contained two eggs, but none was seen with more than two. The egg is light yellowish white, considerably flattened, and ovoid in general outline. Normally the winter is passed in the egg stage but a small proportion of the population overwinters in the form of prepupal larvae in cocoons. A still smaller proportion of the prepupae remains in diapause through a second winter.

With the advent of warm weather the embryo begins to develop, causing the egg to swell until the slit in the needle opens and one side of the egg is exposed. The larva escapes by breaking through the portion of the chorion that is free of the needle.

Upon hatching, the young larvae migrate from the needles in which the eggs have overwintered. In the forest they migrate a distance of several inches to nearby sprays of foliage, where feeding begins near the tips of the old needles. At this stage from three to six larvae usually feed together on a single needle, their heads toward the apex of the needle. The second-instar larvae also have the habit of feeding gregariously, but, for the most part, subsequent instars feed in solitary fashion.

A few eggs had hatched on July 9, 1936, when a field collection was made, but most of them were just beginning to swell and show the dark eye-spots of the developing embryos. A number of the unhatched eggs and a few first instar larvae were collected and taken to the laboratory at Portland where hatching was completed by July 15. Observations were made on the development of larvae that were reared on hemlock foliage in glass jars. Some of these larvae were reared individually, whereas others were reared in groups of 10 or 20. Fresh foliage was supplied daily.

Under laboratory conditions the period from the hatching of the egg to the spinning of the cocoon ranged from 17 to 33 days, with 25 days as about the average. It is believed to be a few days longer in the forest.

Considerable difficulty was experienced in rearing larvae individually, since solitary small larvae were usually unable to initiate attacks upon the hemlock needles. Consequently only five sawflies were successfully reared from egg to adult in isolation. Two of these were females and three were males. In each case there were five feeding instars and a prepupal, nonfeeding instar. One larva that died in the prepupal stage had moulted six times. Averages taken from the individally reared larvae show that the durations of the instars, from the first to the fifth, were 6, 4, 3, 4, and 6 days, respectively.

Since rearing the larvae individually might have had an effect upon the number of molts, an attempt was made to determine the number of larval instars by measurements of 526 frontes dissected from cast larval skins obtained from a mass rearing of sawfly larvae. Many of these larvae were reared from egg to adult, and so there is no doubt that all instars were represented. When these measurements were plotted they formed five fairly well defined groups. It was assumed that these groups might represent the number of larval molts; however, when the measurements of the frontes of the five individually reared larvae were compared

with these groups, it was found that measurements of the frontes of both the fourth and the fifth male instars fell in the fourth group. There is a definite possibility that two female instars were represented in the rather large group 5, especially since the females of several species of *Neodiprion* have one more instar than the males.

When the larva of the last feeding instar reaches full development it becomes restless and moves from needle to needle, eating less and less until the skin is shed and the prepupal, or nonfeeding, larva emerges. This larva differs considerably from the last feeding form by being shorter and unicolorous light green instead of striped. (On the basis of comparative head-capsule measurements, Hopping & Leach (1936) mistakenly concluded that the striped, full-grown larva and the prepupal larva in the cocoon are of the same stage.) The prepupal larva migrates down the tree trunk, or may drop to the ground in search of a place to pupate. A certain number form their cocoons on needles and small twigs, but these are fastened loosely so that by spring practically all have fallen to the ground. Most of the larvae spin their cocoons under moss and bark plates at the bases of trees or in the duff on the ground. Most of the cocoons on the ground are in the first inch of duff. A few are somewhat deeper, but none has been noted in the mineral soil.

The prepupal larva transforms to the pupa inside the cocoon. Although duration of the pupal period is not known, observations were made on the length of time spent in the cocoons by 75 individuals that spun in 1936 and emerged the same fall. The shortest time spent in the cocoon was 23 days, the longest 52 days, and the average 38 days. In another lot of material one individual spent only 16 days in the cocoon. Under laboratory conditions, larvae that spun first took considerably longer to emerge than those that spun last, and so most of the adults emerged during a comparatively short period. No marked difference was found between the time of emergence of the males and that of the females. Relatively little information is available concerning the proportion of the sexes. In the fall of 1934, 385 sawflies were reared, of which 53.8 per cent were males, whereas in the fall of 1936 a lot of 90 reared adults included 36.7 per cent of males.

NATURAL CONTROL.—Invariably there are numerous natural factors which tend to reduce the numbers of an insect species. Perhaps the most conspicuous of these are adverse climate, disease, predacious enemies, and insect parasites. During this study insect parasites were given particular attention, whereas only cursory notes were made on the other factors.

Neither climatic factors nor disease killed a conspicuous number of *Neodiprion tsugae* during the period when these observations were made. A few diseased larvae were observed but the number was negligible. Predatory mammals, on the other hand, destroyed a large number of *N. tsugae* cocoons, particularly those in the loose duff. It was roughly estimated that about 50 per cent of the cocoons formed on the ground were destroyed by these agents. As contrasted with this, cocoons that were spun under bark plates and under moss on rocks, on solid logs, and on tree trunks overwintered without appreciable damage by mammals. Insect parasites killed a rather high percentage of the population of *N. tsugae*, as will be seen in the following discussion.

INSECT PARASITES.—Data regarding parasitization of *Neodiprion tsugae* were obtained from 3 large collections of sawfly cocoons made near Sweet Home, Oreg., in 1935 and 1936, and sent to New Haven, Conn., for rearing, and from 10 small collections of cocoons reared at Portland, Oreg.

The principal collection in 1935, comprising 7,896 cocoons, was made during the week of September 20, when emergence of both sawflies and parasites was at its height. Most of the cocoons were obtained from foliage and various exposed places. This collection arrived in New Haven on September 29 and the cocoons were immediately set out for rearing. Emergence is summarized in table 1.

In the fall of 1936 two large collections, totaling 13,097 cocoons, were made. Most of these cocoons were taken from the duff at the base of infested trees. The first collection, consisting of 1,827 cocoons, was made on August 25 and the second, consisting of 11,270 cocoons, was made on September 2, 3, and 4. These two lots, which arrived in New Haven on August 28 and September 8, respectively, were reared separately; but as emergence records show no significant differences, they have been combined in table 1.

A comparison of the emergence records from cocoons collected in 1935 and 1936 shows a marked decrease in the relative number of *Itoplectis montana*, and an equally marked increase in the relative numbers of *Exenterus tsugae*, *Aptesis* (*Pezoporus*) *tsugae*, *Stylocryptus subclavatus*, and *Tritneptis klugii* obtained in 1936. Possibly an increase in the last four species at the expense of *I. montana* is indicated, but differences in the time and manner of collection may also be responsible. In 1936 collections were made considerably earlier than in 1935, and most of the cocoons collected in 1936 were obtained from the ground, whereas most of those collected in 1935 were obtained from the foliage. It is significant that all four species which showed a marked relative increase in 1936 are ground-frequenting species.

In spite of the changes in species involved, the total percentage of parasitization for the two seasons was identical. Of the 7,896 cocoons collected in the fall of 1935, 1,035 (13 per cent) produced adults of *Neodiprion tsugae*, 3,057 (39 per cent) produced parasites, and 3,804 (48 per cent) produced nothing. Of the 13,097 cocoons that were collected in the fall of 1936, 3,605 (28 per cent) yielded adults of *N. tsugae*, 5,149 (39 per cent) yielded parasites, and 4,343 (33 per cent) yielded nothing.

A comparatively large number of the sawfly cocoons from Sweet Home produced neither adult sawflies nor parasites. The cocoons which produced nothing in 1935 were not sampled, but 400 of such cocoons collected in 1936 were selected at random and dissected. In 44, there were

Table 1.—Emergence from *Neodiprion tsugae* cocoons collected at Sweet Home, Oreg., and reared at New Haven, Conn.

Species	1935 Collection				1936 Collection			
	Number of Host Cocoons	Number of Adults Emerging		Per cent of Total Cocoons	Number of Host Cocoons	Number of Adults Emerging		Per Cent of Total Cocoons
		Fall	Spring			Fall	Spring	
Host								
Neodiprion tsugae Midd.								
Emerged	*1,035*	*1,035*		*13.11*	*3,605*	*3,570*	*35*	*27.52*
Unemerged	*3,804*			*48.18*	*4,343*			*33.16*
Primary Parasites								
Hymenoptera: Ichneumonidae								
Delomerista diprionis Cush.	1,223		1,223	15.49	1,762	1	1,761	13.45
Itoplectis montana Cush.	1,286	847	439	16.29	367	322	45	2.80
Exenterus tsugae Cush.	36		36	.46	951		951	7.26
Stylocryptus subclavatus (Say)					592	4	588	4.52
Aptesis (*Pezoporus*) *tsugae* Cush.	51		51	.65	435	406	29	3.32
Spilocryptus neodiprionis Cush.	21		21	.27	248	121	127	1.89
Ischnus oregonensis Cush.	2		2	.02	93	21	72	.71
Mastrus neodiprioni Vier.	9		9	.11	31	27	4	.23
Lamachus tsugae Cush.	6		6	.07	22		22	.17
Lamachus oregon Cush.	11		11	.14	10		10	.8
Euceros fasciens Davis	5		5	.06	18	3	15	.14
Diptera: Tachinidae								
Tsugaea nox Hall	35	8	27	.45	157	49	108	1.20
Diplostichus sellersi Hall	1		1	.01	54	30	24	.41
Hyperparasites								
Hymenoptera: Ichneumonidae								
Hemiteles tenellus (Say)	230	47	183	2.91	52	52		.40
Thysiotorus latifrons Cush.	60	32	28	.76	32	13	19	.25
Panargyrops areolaris Cush.	6		6	.07	39	19	20	.30
Gelis ferruginosus (Strickl.)	31	10	21	.39	9	9		.07
Mesochorus sp.	1		1	.01	8		8	.06
Primary Parasites or Hyperparasites								
Hymenoptera: Pteromalidae								
Tritneptis klugii (Ratz.)	40		366	.51	263	60	2,732	2.01
Status Unknown								
Hymenoptera: Pteromalidae								
Amblymerus verditor (Nort.)	3	26		.04	5	53		.04
Hymenoptera: Ichneumonidae								
Undetermined					1		1	.01
Total Parasites Emerged	*3,057*	*970*	*2,436*	*38.71*	*5,149*	*1,190*	*6,536*	*39.32*
Total	7,896			100.00	13,097			100.00

dead sawfly pupae or unissued adults, in 92, there were sawfly larvae that had died from an undetermined cause, in 4, there were living parasite larvae that had remained in diapause, and in 260, there were both dead sawfly larvae and dead external parasite larvae. Whether the mortality among the unparasitized sawflies was normal or whether it was due to methods used in handling was not determined. The large number of cocoons in the sample containing both dead sawfly larvae and dead external-parasite larvae indicates that the total parasitization was much greater than that shown by emergence of adults. In the main rearing from cocoons collected in 1936, 5,149 cocoons (39 per cent) produced adult parasites, but it is estimated on the basis of the 400 dissected cocoons that approximately 8,015 (61 per cent) of the contained sawfly larvae were killed by parasites.

Ten small collections of *Neodiprion tsugae* totaling 6,447 cocoons, were made during 1934, 1935, and 1936 and reared at Portland, Oregon. They showed the presence of the same species of parasites at two collection points, 6 miles apart, and provided a comparison of the species of parasites emerging from cocoons collected on the ground and on the foliage. *Itoplectis montana*, although a common parasite in the cocoons formed on the foliage, is almost nonexistent as a parasite in cocoons formed on the ground. *Tritneptis klugii*, on the other hand, more commonly parasitizes insects in cocoons formed on the ground.

Hopping & Leach (1936) recorded five hymenopterous parasites (*Delomerista* sp., *Phaeogenes hariolus* Cress., *Phaeogenes articus* Cush., *Pezoporus* sp., and *Olesicampe* sp.) from cocoons of the western hemlock sawfly taken on the Queen Charlotte Islands. Of these, *Delomerista* sp. and *Pezoporus* sp. were probably the same species as those reared from the Oregon material. Therefore, in the two recorded outbreaks of this sawfly, 23 species of parasites have been reared, 13 of which were previously undescribed. Recently Cushman (1939, 1940) described nine of the ichneumon flies herein listed and D. G. Hall (1939) described the two tachinids. The latter are the only Diptera that have been reared from the hemlock sawfly to date.

BIOLOGICAL NOTES ON PARASITES.—Notes regarding the life history of the various parasites of *Neodiprion tsugae* were made whenever possible. Most of the species emerged in such small numbers that only fragmentary notes were obtained, but in a few cases the life histories can be fairly well indicated.

Tsugaea nox Hall is a tachinid fly which spends the winter as a second-instar maggot within the host prepupa. Feeding is completed in the spring and the full-grown maggot cuts its way out of the host cocoon. The puparium is formed in the soil. Adult flies mate readily under laboratory conditions. Females oviposit on active larvae, laying external, thin-shelled eggs, which contain fully developed maggots. The young maggots hatch almost immediately and bore through the host larva's skin within a few minutes. Apparently there is only one generation a year, although a few flies issued the same fall that host cocoons were collected.

Diplostichus sellersi Hall, another tachinid fly, was not mated in the laboratory, and its life history was not worked out. It lays a white, macrotype egg on the host larva's skin.

Itoplectis montana Cush. is an ichneumonid parasite belonging to the tribe Ephialtini. Adults mate readily under laboratory conditions. Females eagerly attack exposed sawfly cocoons of several species, boring through the cocoon and laying a large egg within the host prepupa. Under laboratory conditions cocoons buried under about one-fourth inch of peat moss were attacked, but field records indicate that exposed cocoons are more readily parasitized. The winter is spent as an immature larva, and development is completed the following spring. Adults issue from the host cocoons. Apparently more than one brood may develop during a season, for many cocoons collected in the field produced *Itoplectis* adults the same fall.

Delomerista diprionis Cush. is an ichneumonid fly belonging to the tribe Ichneumonini. Adults mate readily in the laboratory, and females attack host cocoons, laying a large egg externally on the host prepupa. The parasite larva feeds externally on the host prepupa, completing development and spinning a light cocoon within the host cocoon. The winter is spent in this stage. Pupation takes place in the spring, and the adult parasite

emerges after cutting an exit hole in the host cocoon. There is only one generation a year.

Exenterus tsugae Cush., *Euceros fasciens* Davis, *Lamachus oregon* Cush., and *Lamachus tsugae* Cush. are all ichneumonids belonging to the subfamily Tryphoninae. They attack active host larvae, but complete development after the host cocoon is spun. With the exception of *E. tsugae*, they were obtained in small numbers. Nothing was learned regarding their life histories, for *E. tsugae* was the only one that oviposited, and none of the eggs developed further. The eggs were laid on the host larva partly imbedded beneath the cuticle.

Spilocryptus neodiprionis Cush., *Aptesis* (*Pezoporus*) *tsugae* Cush., *Mastrus neodiprioni* Vier., *Stylocryptus subclaratus* (Say), and *Ischnus oregonensis* Cush. are ichneumonids of the subfamily Cryptinae. All of them have very similar life histories, which are very nearly identical with that described for *Delomerista diprionis* Cush. Apparently they are all multi-brooded, for a considerable number issued the same fall that host cocoons were collected.

Gelis ferruginosus (Strickl.) and *Hemiteles tenellus* (Say) are also Cryptinae. They have life histories similar to those of the five species in that tribe that have already been mentioned, but they develop as hyperparasites.

Nothing was learned regarding *Mesochorus* sp., *Thysiotorus latifrons* Cush., and *Panargyrops areolaris* Cush., but probably they are all internal hyperparasites.

Tritneptis klugii (Ratz.) is a chalcidoid parasite belonging to the family Pteromalidae. Recently Gahan (1938) discussed the taxonomic status of this genus and species. *T. klugii* attacks host cocoons, paralyzing and then laying a number of eggs externally upon the host prepupa. The parasite larvae feed externally, pupating within the host cocoon. If a parasite larva of another species is present in the sawfly cocoon, *Tritneptis* develops on it in the same manner, and apparently it is more often a hyperparasite than a primary parasite. Fifty cocoons which produced *Tritneptis* were dissected. In 5 of them it may have developed as a primary parasite, but in 45 the remains of a solitary primary parasite were found. Several broods may develop during the season. An average of 11 adults issued from 263 cocoons parasitized by this species in 1936, but 39 isolated cocoons gave an average of 20 adult *Tritneptis*, with a maximum of 51 and a minimum of 7.

Amblymerus verditor (Norton) is also a gregarious chalcidoid belonging to the family Pteromalidae. Oviposition by this species was not effected.

Table 2.—Liberations of parasites of *Neodiprion tsugae*.

Host Species	Parasite Species	Liberation Point	Liberation Date	Number Liberated
Diprion polytomum	*Itoplectis montana*	Orange, Conn.	Oct. 20 and Nov. 8, 1935	342
		Kent, Conn.	Nov. 8, 1935	290
		Petersham, Mass.	Sept. 24, 1936	200
		Tupper Lake, N. Y.	April 23, 1936	413
	Delomerista diprionis	Orange, Conn.	June 22, 1936	348
		Tupper Lake, N. Y.	June 23, 1936	330
		Eastford, Conn.	June 21, 1937	500*
Neodiprion sertifer	*Delomerista diprionis*	Far Hills, N. J.	July 2, 1937	400*

* Mated females.

LIBERATIONS OF PARASITES.—Since *Itoplectis montana* and *Delomerista diprionis* seemed to be potent factors in controlling *Neodiprion tsugae* in Oregon, several colonies of these parasites were liberated in infestations of *Diprion polytomum* (Htg.) in the northeastern part of the United States, and one colony of *Delomerista diprionis* was liberated in an infestation of *N. sertifer* (Geoff.) in New Jersey. *D. polytomum* is presumably an introduced species which has become a serious menace to spruce in eastern Canada and the northeastern part of this country. *N. sertifer* is an European species which is now known to occur in New Jersey, Ohio, and Michigan. Laboratory experimentation indicated that *I. montana*

does not develop normally as a parasite of *D. polytomum*, but this parasite is also an important enemy of several lepidopterous defoliators on the Pacific Coast, and might be generally valuable in the northeastern forests. Records obtained from the Division of Insect Identification indicate that *D. diprionis* is already present in the northeastern United States and in Canada. The liberations are shown in table 2.

SUMMARY.—Stands of western hemlock *Tsuga heterophylla*, near Sweet Home, Oregon, were seriously defoliated by *Neodiprion tsugae* Middleton during the period 1933 to 1936. Since *N. tsugae* feeds chiefly on old foliage, few trees died. There is one generation a year in Oregon. Adults emerge and deposit eggs in hemlock needles early in the fall, and the winter is spent in the egg stage. The eggs hatch early in July and the larvae complete their development and spin their cocoons in August or September. Most of the cocoons are spun in the forest litter, but a few are fastened to foliage. A small proportion of the population overwinters as prepupal larvae in cocoons.

During 1935 and 1936 large collections of *Neodiprion tsugae* cocoons were made at Sweet Home, Oregon, and sent to New Haven, Connecticut, for rearing. Parasites emerged from about 39 per cent of the cocoons in both collections, but dissections showed that about 61 per cent of the contained sawfly larvae had been killed by parasites in 1936. Twenty different species of primary parasites and hyperparasites emerged. *Itoplectis montana* was one of the most important species reared in 1935, when the majority of the cocoons were collected on the foliage. *Exenterus tsugae*, *Aptesis* (*Pezoporus*) *tsugae*, *Stylocryptus subclaratus*, and *Tritneptis klugii* were more important in 1936 when the majority of the cocoons were collected from the forest litter. *Delomerista diprionis* was one of the most important species both years.

Itoplectis montana was liberated at two points in Connecticut, one in Massachusetts, and one in New York where there were infestations of *Diprion polytomum*. *Delomerista diprionis* was liberated at three *D. polytomum* infestations—two in Connecticut and one in New York—and at one *Neodiprion sertifer* infestation in New Jersey.—10-16-40.

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ADVANCES IN ENTOMOLOGY

Entomologists not engaged in the chemical study of insecticides and who do not commonly consult literature in the field of chemistry may have failed to see a recent excellent article by Dr. Chas. H. Richardeson, of Iowa State College, published under the above title in the *News Edition*, American Chemical Society.

The article is in the nature of a review of the work published during the past year and having to do with new applications of insecticides and new materials being developed for use in insect control. An extensive bibliography of articles dealing with insecticides and their application, published during the year, supports the discussions.

The article appears in the *News Edition* for January 25, 1941, and may be secured through the American Chemical Society at a nominal price.

The Establishment in Puerto Rico of *Larra americana* Saussure

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On the basis of all available evidence, Van Zwaluwenburg (1918) concluded that the so-called Puerto Rican mole-cricket, or changa, *Scapteriscus vicinus* Scudder, was not native to Puerto Rico, and that the reason it there assumed such importance as an economic pest was because, having been accidentally introduced, it thus escaped natural control by a specific parasite or other enemies. The most logical method of control, therefore, would be by searching in its country of origin for such a parasite and introducing it into Puerto Rico.

Mr. F. X. Williams, of the Hawaiian Sugar Producers' Experiment Station, while searching for a specific parasite of another species of mole-cricket that had become destructively abundant in Hawaii in 1925 first noted the habits of *Larra americana* Saussure as a parasite of *Scapteriscus vicinus*, and its exceptional abundance at Belem, Pará, Brazil (Williams 1928).

When the assignment of federal funds to the Agricultural Experiment Station of the University of Puerto Rico first made financially possible the undertaking of an attempt at the introduction of a parasite of the changa into Puerto Rico, little was definitely known of the actual range of the changa or its parasites in countries nearer than Brazil. It was only gradually that the following information was obtained. The mole-cricket present in Cuba has been shown by Scaramuzza (1936) to be *Gryllotalpa hexadactyla* Perty. As *Scapteriscus didactylus* Latr., a mole-cricket is recorded from Jamaica by Gowdey (1926). The changa is definitely known to be present in Haiti, but climatic and soil conditions suitable to it are so extremely limited in extent that the writer (Wolcott 1938) found it to be very rare. It is also present in some of the Lesser Antilles; St. Kitts, and St. Vincent (specimens in the old collection of the Imperial College of Tropical Agriculture at Trinidad, as identified by the writer), Grenada, St. Lucia and Dominica (specimens in the U. S. National Museum, identified by Mr. A. N. Caudell), but both airplane and steamship communication from any of these islands to Puerto Rico is difficult.

In Trinidad, the area in which the changa occurs in abundance includes Port-of-Spain itself, and extends considerably farther to the east than the Imperial College of Tropical Agriculture at St. Augustine. The lawn of the campus was entirely destroyed by it in large patches in 1936, yet a month's intensive search for parasites, besides extensive collecting there for several years by Mr. D. Vesey-Fitzgerald, a specialist in the Larridae, failed to demonstrate the presence of *Larra americana*.

Scapteriscus vicinus is presumably present in all humid sandy areas of the northern part of South America, but the problem of searching for a parasite and getting the parasite to Puerto Rico is practically limited by the difficulties of transportation. In Venezuela, the region around La Guayra and Caracas is either too arid or too cold, while in eastern Venezuela the first stop of Pan-American Airways, at Caripito, is an oil camp located in a semi-xerophytic forest, with very primitive accommodations for anyone not connected with the oil company. At certain seasons, however, the rainfall here may be considerable, and at such times, the oil men note the changa at lights. Mr. L. F. Martorell did in fact collect *Larra americana* (specimens determined by Miss Grace A. Sandhouse) in small numbers at Caripito, but its scarcity (besides various other considerations) rendered Caripito unsuitable as a base for mass collections. The only other airport in eastern Venezuela is at Guanta, where the surrounding country is cactus-covered stony hills, or alkali desert with a mirage of water that isn't there shimmering in the distance.

In contrast with the general aridity of so much of northern Venezuela, the Guianas normally have an abundant rainfall. The soil of the country immediately around Georgetown in British Guiana, however, is a heavy clay, the generally sandy areas being so far inland that, from

the standpoint of rapid transportation, they are as far away from Puerto Rico as is Belem. Paramaribo, in Dutch Guiana, is located, not on the coast, but far enough inland so that the soil to the south of town at least (when not under water), is sandy. The Puerto Rican changa is present in abundance, as is also *Larra americana*, and indeed Paramaribo might serve for making extensive collections were it not for uncertain weather, and if Belem did not offer other advantages.

Heaviest and most continuous rainfall in Belem comes in March and April, but during the first few weeks of the rainy season (late January and early February), and towards its close (late April, all of May and early June), conditions are practically ideal for *Larra*. Nearly every day has a bright clear morning for collecting the wasps (which are active only in sunshine), and heavy rain in the afternoon or evening which soaks the soil and forces the changas to the surface where they can more easily be attacked by the female wasps.

By the present schedule of Pan-American Airways, planes leave Belem at 8:00 A.M. on Monday and Thursday mornings, and are in San Juan before 10:00 A.M. of the following morning. That is: wasps collected on Sunday and Wednesday mornings in Belem can be released 48 hours later in Puerto Rico. Planes were not always so fast and frequent, but even on the first trip of the writer to Belem in February 1936, returning with 78 adult *Larra* in a Wardian cage containing (in addition to the wasps) moist sand, split stalks of sugar cane and flowers of *Borreria verticillata* which the wasps frequent, 25 survived the 34 hour journey alive, and were released the same day near San Juan.

This initial shipment proved that adults collected in the field in Belem could survive the trip to Puerto Rico, but actually set a most unfortunately high record, never even approached by any succeeding shipment made under comparable conditions during the following years. Indeed, blaming the heavy mortality on exceptionally hot spring weather in Belem, or planes being two days late, or the spraying on the interior of the planes on arrival in San Juan to kill mosquitoes, according to U. S. Public Health regulations, could not obscure the fact that the essential factor in ensuring the survival of the adults in captivity had not been discovered. The discouragingly high mortality of adults *en route*, often total, seemed to threaten the success of the project as thus conducted, and require attack from another angle.

Mr. L. F. Martorell, in Belem in January 1938, repeating the experiments of Mr. F. X. Williams on inducing the females in captivity to oviposit on the host, included with his third shipment of adult wasps some of the parasitized changas thus obtained, in a screened wooden box. The difference in mortality of the adults was wonderful, and most heartening, for all had been dead or very weak in his two initial shipments, and nearly 80 per cent were found by the writer (1938) to have survived when accompanied by parasitized changas. It should be especially noted that such a result was entirely unanticipated; the parasitized changas were included in the shipment of *Larra* adults merely as a means of getting the parasite to Puerto Rico in another stage, which might survive the trip more successfully, and not with any idea of such a remarkable effect on the wasps. No parallel instance is known, and indeed the fact seems so incredible that, had not the invariable low mortality of the wasps attended the presence of parasitized hosts, their inclusion would not have been continued in succeeding shipments.

In the bulk shipments made in May and June 1938 and in May and June 1939, the writer conducted tests using containers of the same size as those used by Martorell (1939) to determine what other factor or factors might be essential for survival of the wasps *en route*. In a shipment lacking food for the wasps (powdered sugar syrup applied like cake-frosting to the inside of the lid of the box) survival was normal. When the bouquet of *Borreria* flowers was omitted, in another shipment, survival dropped to 65 per cent, the value of the flowers being possibly quite as much due to the ample standing or resting room provided as to their being a source of nectar for the wasps.

To determine, if possible, what characteristics of the changas made their presence indispensable, a shipment was prepared in which the screened cage of parasitized mole-crickets was sealed with gummed paper, wrapped and sealed in cellophane, and wrapped and sealed again in patapar. This, it was hoped, would pre-

vent the odor of the changas from reaching the wasps. The survival of *Larra* adults was normal. In a comparable shipment, containing an identical screened cage with moist sand previously inhabited by changas and foul with their excrement and dead and partially eaten bodies, unsealed and unwrapped as in normal shipments up to that time, but *lacking live changas*, all wasps were dead when it reached its destination. The human nose does not distinguish between the odor of changa excrement and that of the live insect itself, but either the wasps do, or smell is not the sense by means of which they recognize the presence of the host.

In close captivity with others, changas often chirp and trill, but the solitary changa in captivity is silent. A shipment of *Larra* adults comparable to others, but with all changas in individual tin cans (salve boxes) with a bit of moist sphagnum moss, and presumably silent *en route*, was received in San Juan with the highest recorded survival of wasps up to that time. It would appear that the wasps are unerringly aware of the presence of live changas regardless of the character of the container, or how securely they are wrapped and sealed, or whether they chirp or are silent. How the wasps do this, and why it should cause them to remain alive in captivity are still unsolved problems.

Its practical value, however, in the solution of this particular problem of parasite introduction is shown by the following comparison. Out of a total of 711 wasps shipped unaccompanied by parasitized hosts, 643, or over nine-tenths, died *en route*, and only 68 survived. Of the 2,319 field collected wasps sent from Belem accompanied by changas, each of which had been parasitized in captivity, 1,931, or 83.7 per cent, arrived in San Juan alive.

By January 1939, unquestioned establishment of *Larra americana* Saussure in Puerto Rico from releases made in May and June 1938, and earlier, was indicated by finding wasps in considerable abundance at two points: to the south of Laguna San José, near Río Piedras, and at Maleza Farm near Isabela. With establishment assured at two points, the maximum benefit was naturally to be obtained by duplicating large releases elsewhere. From the even larger shipments made in May and June 1939, releases were made of from 200 to over 300 wasps, plus 60 to 100 parasitized mole-crickets at each of the following points: (1) across the harbor from San Juan at Palo Seco (Isabela Grove), (2) near the beach between Luquillo and Mameyes, (3) between Juncos and Naguabo near Río Blanco at two points, (4) up the valley from Yabucoa, at Barrio Laura, (5) in the plant breeding garden at the Experiment Station at Río Piedras, and (6) southeast of Laguna Tortuguero between Manatí and Vega Baja.

Despite intensive search at each of these points nearly every month since, we can be sure of establishment only in the sandy land near Laguna Tortuguero. A careful consideration of the possible reason or reasons why establishment has taken place at three points in Puerto Rico, and not at five others where releases of equal size and promise were made, appears to indicate the cause to be the excessive pressure of the human population on land in the limited area of Puerto Rico. The *Larra* wasps in Brazil are very particular about just what clumps of *Borreria* they frequent, and, if one is to collect them in sufficient numbers for shipment, these preferences must be discovered and taken advantage of. Along the railroad right of way and in the middle of the excessively broad streets of outlying Belem, bushes of *B. verticillata* often become shoulder-high, while in Puerto Rico they rarely have the opportunity to become more than knee-high. The increasingly intensive use of pastures in Puerto Rico which involves the elimination of *Borreria* bushes by mowing them down or pasturing them out, is presumed to be the reason why establishment of *Larra* failed at two points where *Borreria* bushes were high at the time of release, but had almost disappeared a few months later.

Soil appears not to be the controlling factor. The grey sandy soil near Laguna Tortuguero and near Laguna San José is Algarrobo fine sand, but that at Maleza Farm is reddish in color, called Maleza fine sandy loam. The former is so lacking in organic material as to furnish only scanty pasturage, but near Río Piedras finds a specialized use for the growing of ornamentals, while near Vega Baja its lack of agricultural value is indicated by its use for the National Guard as Camp Padilla. The Maleza fine sandy loam was formerly largely planted to yarey hat palms, but with irrigation water available,

most of it has been planted to sugarcane. At Maleza Farm, the releases of *Larra* were made at the reservoir, the banks of which were allowed to grow high with *Borreria*. The acquisition of Maleza Farm, and of an extensive surrounding area by the United States Army for the construction of the Punta Borinquen Air Base at first appeared to threaten the continued existence of *Larra* in this region because irrigation water was cut off, and the reservoirs remained empty. Actually, conditions were infinitely improved for *Larra*, for, preliminary to construction, much of the sugarcane was removed and the land allowed to grow up in weeds. By the spring of 1940, *Larra* adults were noted a mile east of the original point of release, and half a mile west, and in May were so common on a small area of ground that had been scraped bare and was full of changas, that 60 were collected there in a few hours, for re-release an hour later at the Isabela substation. This particular spot is now part of the main airplane runway, but from an area adjacent to it, high in *Borreria* in October 1940, an additional collection of adults was made, also for release at the substation. Eventually, of course, the airplane base may prove less desirable for *Larra*, but at least while construction is still in progress and weeds have a chance to grow luxuriously and form dense and high clumps loved by the wasps, the prospect is most favorable.

Until recently, the prospect for the further dispersion of the wasp appeared not too bright, as elsewhere *Larra* adults have been noted exactly where the releases were made, or not more than a few hundred yeards away, presumably indicating that the most favorable point for release had been chosen. In January 1941, however, adults were seen to the west of Laguna Tortuguero, on the flowers of *Hyptis atrorubens* close to the ground (not knee- to waist-high as they flower in Belem when frequented by *Larra*), four miles in a direct line from the point of original release and in an environment almost exactly similar. A few days later, they were seen on *Borreria* flowers growing along the edge of the cliff above the coast at Isabela, seven miles east and against the direction of prevailing winds from the point of original release at Maleza. This is in an environment quite dissimilar from the low swampy banks of Laguna Tortuguero, being on the edge of a high, rocky cliff, on a narrow strip of *Borreria* bushes left at the edge of plowed fields where the turn was made at the end of the furrow. Their presence here suggests the desirability of farmers leaving such a strip of unplowed weeds at the ends of all fields in the Isabela district where the aid of *Larra* in parasitizing changas is desired. Indeed, it brings the *Larra* introduction out of realm of theoretically possible in non-agricultural sandy wastes (Maleza means "wilderness") into the immediate practicality of help to the average small farmer of the Isabela district, and eventually of all humid portions of Puerto Rico where the changa is established as a major crop pest. —12-9-40.

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Dr. B. D. Burks, Assistant Entomologist of the Illinois Natural History Survey, is spending six weeks in Washington, D. C., on a temporary appointment with the U. S. Department of Agriculture Bureau of Entomology and Plant Quarantine. He will return to the Natural History Survey in Urbana the first of April.

As Associate Entomologist with the Bureau, Dr. Burks will resume the work of classifying the genus *Tetrastichus*, which he began in the spring of 1938 on a similar appointment.

Dr. Burks is the author of *Revision of the Chalcid-Flies of the Tribe Chalcidini in America North of Mexico*, published by the Smithsonian Institution.

The Effect of Varying Conditions on Oviposition by *Trichogramma* on Eggs of Angoumois Grain Moths*

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A consideration of the rearing of *Trichogramma minutum*, Riley (dark variety), having revealed the necessity for further information upon the egg laying habits of the adults, series of experiments were designed to yield information upon some of the more pressing questions. The points singled out for investigation were the effect of varying the parasite population while maintaining a constant number of host eggs; the effect of age on parasitization; the effect of storage temperature on parasitization, and the effect of sulphur on parasitization.

Methods.—Known numbers of freshly laid host eggs (one day old, except those reported in Test 7), from pure cultures, were exposed to known numbers of parasites in petri dishes. The eggs were evenly distributed over the bottoms of these dishes. Light was supplied by a 100-watt electric bulb, except in test No. 5. The eggs parasitized were counted and the percentage of parasitism calculated accordingly. In the first experiment (Table 1) the host egg density was kept constant at 500 while the female parasite population was varied. In the remainder of the experiments (Table 2) number of eggs and number of female parasites remained constant at 100.

All experiments were triplicated in 5-inch petri dishes and kept in a specially built cabinet where the temperature could be maintained at or near 80°F. with a relative humidity of about 70 per cent, with the exception of test No. 4. In the experiment from which the data in table 1 were collected the three cultures were used in each series. In the six others, three cultures were used in each series and the series repeated three times. The data presented are averages of three observations in table 1 and of nine observations in each of the other tests summarized in table 2.

Discussion of Results.—The results in table 1 show that the greater the number of parasites liberated, the host density remaining constant, the larger the number of eggs parasitized, and hence, the higher the percentage of parasitism. There is a progressive increase of parasitization percentage from inoculations in which the host outnumbered its parasite four times to the one in which the parasite population was twice the host's. This increase is slight (3.34 per cent) for the first three inoculations in table 1. The progression became marked (11.13 per cent) at the point where the parasites began to outnumber the host. The last three cases, including the one just referred to, show also a progressive increase in parasitism very close to the same in the first three cases already cited (4.53 per cent). There is not a single case showing 100 per cent parasitism. The larvae which emerged within 5 days from the time the inoculations were made show the eggs from which they hatched to have remained untouched by the parasites. Furthermore, those eggs that hatched evidenced their viability.

Table 1.—The effect of varying the relative number of host eggs and parasites present on percentage of parasitization. Each lot of host eggs contained 500 eggs; the number of parasites was varied as shown. Host eggs were all one day old.

Number of Parasites	Eggs Parasitized			Larvae Hatching in 5 Days
	Number	Per cent	Average	
100	359	71.80		25
100	320	64.00	68.47%	11
100	348	69.60		7
200	306	61.20		6
200	359	71.80	71.47%	13
200	407	81.40		13
400	354	70.80		5
400	368	73.60	74.87%	2
400	401	80.20		12
600	429	85.80		14
600	412	82.40	86.00%	1
600	449	89.80		7
800	462	92.40		0
800	441	88.20	90.53%	3
800	453	90.99		1
1000	445	89.00		16
1000	483	96.60	93.87%	0
1000	480	96.00		9

In table 2, test No. 1 displays the fact that the percentage of parasitism of freshly laid eggs is relatively high.

The data for No. 3 show that eggs which had been stored for 18 days in an electric refrigerator at 38°F. are still parasitized, but less so than freshly laid eggs.

* Published with the approval of the Director as Journal Article No. 477 (N.S.) from the Michigan Agr. Expt. Sta.

Table 2.—Parasitization of grain moths by *Trichogramma* under a variety of conditions. Nine lots of eggs, arranged in three series, each lot consisting of 100 eggs and 100 parasites, were used in each test. Relative humidity was near 77 per cent in all tests. Eggs one day old except in Test No. 7.

TEST NO.	2	3	4	5	6	7
Lighting	Light	Light	Light	Darkness	Light	Light
Temperature	80°F	80°F	68°F	80°F	80°F	80°F
Other Variable	None	After 18 days at 38°F	None	None	Eggs on Sulphured Wheat	Eggs 4 days old
			Percentage of Parasitization			
	80%	75%	10%	9%	3%	0%
	78	78	27	13	5	2
	83	71	19	8	3	2
	71%	80%	33%	0%	1%	0%
	86	71	14	15	9	1
	77	81	26	8	6	0
	93%	72%	16%	10%	8%	3%
	88	76	20	9	8	1
	88	82	15	7	2	1
Average	82.7%	76.2%	20%	8.8%	6.0%	1.1%

The *Trichogramma* parasites are active in a temperature of 68°F. than at 80°F. (Test No. 4).

The parasite is not very efficient in the absence of light, as the results of test No. 5 reveal. Test No. 2 is a check to test No. 5 all things in both experiments being the same, except for light conditions.

Trichogramma parasitizes eggs produced on sulphured wheat (test No. 6) but the percentage is very low.

The lowest parasitization percentage shown in any of the seven experiments (1.11 per cent) was obtained with the host eggs exposed 4 days after being laid, judging by the data from test No. 7.

SUMMARY.—An apparent correlation exists between abundance of parasites and parasitization of host, other things being equal.

Trichogramma minutum falls short of 100 per cent efficiency when confined in a petri dish having two female parasites to each Angoumois grain moth egg. Smith & Flanders (3), have reported that even when the host eggs are confined in the small space of a petri dish, and this environment is stocked with one adult parasite to each four host eggs, *Trichogramma* still fails to effect 100 per cent parasitization.

The efficiency of *Trichogramma* in locating its host is considerably greater in the light than in darkness as is indicated by the data from tests 2 and 5. This might be explained on the basis of greater activity in the presence of light which results in a greater dispersion. It can not be logically explained on the assumption of an increase of vision, since it is generally accepted that *Trichogramma* finds its host almost entirely by random movements (Flanders 1929; Smith & Flanders 1931); or as Barber (1936) has pointed out, the host eggs are reocgnized only when the adult parasites come upon them.

From a study of the results of these experiments the conclusion is drawn that *Trichogramma minutum* is not equally efficient as a parasite in all environments and that its response to the environment determines, to a great extent, its parasitic potential.—10-28-40.

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Fumigation of Purple Scale with Hydrocyanic Acid[1]

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Purple scale, *Lepidosaphes beckii* (Newm.), is considered to be the third most important citrus scale pest in California, the most important in Florida, and a serious pest in many of the citrus areas throughout the world. Its occurrence in the southern California citrus area is limited to the coastal section, and it is not found in Riverside or San Bernardino counties, which are more interior (Quayle 1938). In California, the general recommendation for the control of the purple scale is to fumigate in midsummer or early fall or to combine this treatment with an oil spray in the case of heavy or persistent infestations.

A review of the literature on the purple scale disclosed very little pertaining to experimental fumigation work on this insect. Woglum (1912) states that in his experiments with purple scale he found that

> " . . . all insects were destroyed on the leaves and branches by a three-quarter-ounce [potassium cyanide] dosage rate, that all insects and over 99 per cent of the eggs were destroyed at a 1-ounce dosage rate, and that all eggs on the leaves and branches were destroyed at a 1¼-ounce dosage rate. Very little fruit was on the trees, yet, where present, normal eggs were found on the fruit after a dosage as high as a 1¾-ounce rate."

Woglum (1923) also says that

> " . . . if we except the winter months, purple scale eggs are readily destroyed by cyanide gas."

During 1939 it was found that purple scale could be reared in the laboratory by the use of methods very similar to those employed in the rearing of California red scale, *Aonidiella aurantii* (Mask.), for experimental purposes (Lindgren 1938). Life-history studies were made under controlled conditions, and since purple scale is a serious pest of citrus in California and fumigation with hydrocyanic acid gas is the chief method of control, a series of experiments was conducted to determine the factors which affect the fumigation results.

Purple scale did not reproduce satisfactorily in the rooms used for red-scale stock and held at low relative humidity (30 per cent); but in rooms held at high relative humidity (80 per cent), it was reared successfully. Under these conditions, that is, at 80°F. and 80 per cent relative humidity, the scale started to lay eggs at 36 days and at 44 days the eggs began to hatch.

Although Bodenheimer & Steinitz (1937) state that in Palestine the purple scale females do not require fertilization to reproduce, since "parthenogenesis occurs quite freely," this was not found to be the case in California. Twenty-five females just past the second molt were covered by glass cells, and the grapefruits on which they were living were placed on insect-proof cages and held until the insects were 60 days old, or 24 days past the time for egg-laying to begin and 16 days past the time that eggs ordinarily begin to hatch. They were found to have developed a normal covering and to have full-sized bodies, but to have deposited no eggs. The introduction of males at this time resulted in normal egg deposition.

Relative Susceptibility of Different Stages of Purple Scale to HCN Fumigation.—August and September are usually the months preferred for treatment of the purple scale, since in most years there is a pronounced hatch at that time, and it is believed that the young scale succumbs readily to fumigation. As very little is known about the relative resistance of the various stages of purple scale to HCN fumigation, a series of experiments was conducted in which insects of twelve age groups (Table 1) were fumigated together. Two fumigations at different concentrations of HCN were carried on in one day. A 100-cu. ft. fumatorium was used, and exposure was for 40 minutes at a temperature of 75°F. After fumigation, the treated, infested grapefruits were held at 70° to 74°F. for about 20 days and were then examined to determine the percentage of insects killed. As the scales were counted, each scale was turned over with a needle and the body was pressed to determine whether the insect was alive or dead. Results of these tests are presented in table 1.

Purple scales of different ages vary greatly in their susceptibility to HCN

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fumigation (Table 1). In general it can be said that day old scales that have just settled, scales in the late first and second molts, and mature adults are the most difficult to kill; while those insects in the early first and second molts, those in second instar, and those between the second molt and mature adult are most susceptible. There is a rapid increase in resistance to fumigation from the beginning to the end of the molting period, especially during the second molt. Individuals that are 28 days old and have practically finished forming the scale covering are relatively easy to kill, but from this time until they are mature and producing eggs, they become increasingly difficult to kill.

Table 1.—Relative resistance of purple scale of twelve age groups to fumigation with two different concentrations of HCN. Insects counted in these tests totaled 42,423.

(Exposure, 40 minutes, at 75°F.)

Age of Scales, in Days	Stage of Development	Mean Per Cent Kill: HCN, 0.20 Milligrams Per Liter	Mean Per Cent Kill: HCN, 0.37 Milligrams Per Liter
1	Very early, just settled	62.13	71.11
4	Early first molt	88.50	96.95
8	Late first molt	56.80	69.00
12	Second instar	96.00	96.95
16	Early second molt	99.70	99.70
20	Late second molt	49.55	55.95
24	Just past second molt	65.13	93.13
28	One third of last covering formed	96.80	97.27
32	Almost mature—no eggs present	84.30	92.70
36	Mature, few eggs laid	57.33	72.60
40	Mature, many eggs laid	46.00	61.55
44	Mature, some eggs hatching	40.67	61.94

A few experiments were conducted on purple scale crawlers to determine their susceptibility to HCN fumigation. The crawlers were placed on fruit and were fumigated immediately. The number of those that settled or became established was checked 2 to 3 weeks after fumigation. Purple scale crawlers proved to be very susceptible to fumigation: at a concentration of 0.14 milligrams HCN per liter for 40 minutes, 99.3 per cent of the crawlers were killed; at the same concentration and with an exposure of 20 minutes, 98.7 per cent mortality was obtained. This is of particular interest because the young scales that were not over 24 hours old but had settled were surprisingly difficult to kill by fumigation (Table 1). The activity of the crawlers may be a factor in their susceptibility, since the waxy scale covering formed immediately after settling is loose and flimsy and offers no protection to the insect beneath it.

Because of the overlapping of generations in the field, it is difficult to conclude from the results given in table 1 at what time of the year the purple scale is most vulnerable to fumigation. Field observations over a period of years indicate, however, that in California the most satisfactory control is obtained during late July and early August, when the majority of scales have probably not yet reached the second molt, but most of the eggs have hatched.

Various dosages of HCN were tried on 22-day old scales, just past the second molt, and on mature, 43-day old scales, these age groups being chosen arbitrarily. The results are given in table 2. Each experiment was replicated at least four times. The data obtained show that at concentrations of gas up to 0.71 mg. per liter, the kill of the younger scales was greater than that of the mature scales; whereas at the higher concentrations (0.92 and 1.09 mg. per liter), greater percentages of mature scales were killed. It is interesting to note that increasing the concentration of HCN from 0.71 to 1.09 mg. per liter caused an increase in kill of only 1.66 per cent in the younger scales, while in the case of the mature scales the increase in kill was 7.45 per cent.

Table 2.—Effect of increased concentrations of HCN in fumigation of purple scale of two age groups. Total number of insects counted 19,280.

(Exposure, 40 minutes, at 75°F.)

HCN, Milligrams per Liter	Per Cent Kill: Scales Just Past Second Molt (22 days old)	Per Cent Kill: Mature Scales (43 days old)
0.20	63.74	53.88
0.37	89.56	63.74
0.55	93.05	87.15
0.71	97.14	92.55
0.92	97.23	99.60
1.09	98.80	100.00
1.18	—*	100.00

* Data not available.

A concentration of 0.92 mg. of HCN per liter, which is the approximate average concentration obtained in the field with an 18-cc. schedule, did not give a complete kill of either the 22-day scales, just past the second molt, or the 43-day, ma-

ture scales. Other tests indicate (Table 1) that there may be scales in other stages of development, such as the late second molt, which may be even more difficult to kill at this higher concentration of HCN.

STUPEFACTION TESTS.—It is recognized that the California red scale exhibits a characteristic known as "protective stupefaction" (Gray & Kirkpatrick 1929); that insects of this species which are exposed to a sub-lethal dosage of HCN preceding the lethal dosage are rendered more difficult to kill than those which have not been so exposed. Protective stupefaction has also been found in the granary weevil, *Sitophilus granarius* (Linn.), by Peters (1936) and in the black scale, *Saissetia oleae* (Bern.), by Gray & Kirkpatrick (1929). This is an important factor in commercial fumigation, since, in the orchard, scale insects soon to be fumigated are often exposed to drift gas.

To the authors' knowledge, no work on the occurrence of protective stupefaction in purple scale has been reported; hence the tests described here were made to determine whether this phenomenon might be found in these insects.

Mature female purple scales, 34 to 38 days old, were subjected to a low or sub-lethal concentration of HCN for 5 minutes, followed by a lethal concentration for 40 minutes; other scales of the same age were exposed to the lethal concentration only. Experiments were carried out in three groups: with no time interval and with 1 hour and 2 hours between the sub-lethal or so-called "stupefying charge" and the lethal charge of HCN. The sub-lethal concentration was similar to that used on the red scale (Lindgren 1938), in which protective stupefaction was very apparent.

From the data presented in table 3, it may be observed that under the conditions of these experiments the scales that were exposed to a low concentration of HCN gas for 5 minutes and then fumigated were no more difficult to kill than those scales that were not exposed to the low concentration of HCN prior to the lethal concentration. This indicates that protective stupefaction does not occur in the purple scale. In fact, it appears from these experiments that the preliminary sub-lethal charge contributed slightly to the kill of the purple scale.

Table 3.—Fumigation of mature purple scale with varying interval between sub-lethal and lethal changes.

(Sub-lethal charge, 0.10 mg. HCN per liter for 5 minutes; lethal charge, 0.37 mg. for 40 minutes.)

GROUP	FUMIGATION TREATMENT	INTERVAL BETWEEN SUB-LETHAL AND LETHAL CHARGES	NUMBER OF EXPERIMENTS	TOTAL NUMBER OF SCALES EXAMINED	MEAN PER CENT KILL
1	Lethal charge (control)	—	6	6,000	86.46
	Sub-lethal charge followed by lethal charge	None	6	4,818	95.48
2	Lethal charge (control)	—	5	6,600	88.84
	Sub-lethal charge followed by lethal charge	1 hour	5	5,915	96.80
3	Lethal charge (control)	—	6	6,050	89.46
	Sub-lethal charge followed by lethal charge	2 hours	6	6,705	92.10

EFFECT OF PRECONDITIONING SCALE.—A series of experiments was conducted to determine the effect of temperature on HCN fumigation of the purple scale. Scales 22 days old, just past the second molt, and mature scales 43 days old were used in these experiments. The infested grapefruits were exposed to preconditioning temperatures of 50°, 75°, or 90°F. for 3 to 5 hours prior to fumigation. During the 40-minute fumigation period, the large fruits tended to remain at the temperatures at which they had been preconditioned, with gradual changes in temperature in the direction of the fumigation temperatures of 75° or 90°F.

The percentage kills of the 43-day in-

Table 4.—Effect of preconditioning on mortality of 22-day and 43-day old purple scale fumigated with HCN.

HCN, Mg. per L.	Temperature		23,715 22-Day Scales		18,927 43-Day Scales	
	Preconditioning	Fumigation	Number of Tests	Mean Per Cent Kill	Number of Tests	Mean Per Cent Kill
0.36	50°F	75°F	5	89.78	7	96.12
	75	75	5	89.56	7	63.74
	90	75	5	81.95	7	54.57
0.37	50	90	4	96.75	6	98.20
	75	90	4	89.87	6	91.06
	90	90	4	75.20	6	81.98
0.71	50	75	4	99.85	4	97.87
	75	75	4	97.14	4	92.55
	90	75	4	91.32	4	82.50
0.71	50	90	5	99.88	4	99.95
	75	90	5	98.88	4	98.75
	90	90	5	90.44	4	99.95

sects, obtained under these conditions, are shown in table 4. In general, those insects preconditioned at 50°F. were more easily killed than those preconditioned at 75°; while the latter, in turn, succumbed more readily than those preconditioned at 90°. On the other hand, a temperature of 90°F. during fumigation resulted in a higher mortality than did a fumigation temperature of 75°.

The results of the tests on the 22-day scales, just past second molt, are also shown in table 4. The effect of the preconditioning temperatures on the younger scales was similar to that shown for the older scales, but was not so pronounced.

Preconditioning at 50°F. appears to increase the kill of scale by fumigation, while preconditioning at 90° decreases it. Fumigation temperatures (75° or 90°F.) appear to have little effect on results.

FUMIGATION OF PURPLE SCALE EGGS.—The problem of killing purple scale eggs by fumigation is important, since it is believed by some that the egg is the stage most likely to survive field treatments.

Under the rearing conditions used in these experiments, the females were found to produce their first eggs on the thirty-sixth day after settling and to have produced about 20 eggs each by the thirty-seventh day. On this day, the eggs from a number of females were removed to petri dishes, one of which was used for each experiment. As soon as the eggs were in the petri dishes, these dishes were placed on ruled black paper, and the eggs were counted. Eggs were then either fumigated immediately or held the required number of days at a high relative humidity and then fumigated. In some tests, the eggs were fumigated under the scale covering; these eggs were removed to the petri dishes and counted immediately after fumigation. The petri dishes containing the fumigated eggs were placed in a room at high relative humidity (80 per cent) and held until hatching was complete. The hatch was checked by counting the empty chorions. The eggs were not injured by handling, since checks showed 97.1 per cent average hatch.

To determine the relative susceptibility of scale eggs of different ages to fumigation with HCN gas, eggs up to 1 day old were placed in petri dishes and held until

Table 5.—Relative susceptibility of purple scale eggs of different ages to fumigation in a 100-cu. ft. fumatorium with HCN. Total number of eggs checked, 11,968.

(Exposure, 40 minutes, at 75°F.)

Age of Eggs, Days	Mean Per Cent Kill	
	0.36 mg. HCN Per Liter	0.71 mg. HCN Per Liter
0 to 1	17.15	89.95
1 to 2	16.45	100.00
2 to 3	35.13	99.84
3 to 4	22.51	100.00
4 to 5	66.15	100.00
5 to 6	72.55	100.00
6 to 7	70.72	100.00
7 to 8	69.27	100.00
8 to 9	81.47	100.00

they reached the desired age; they were then fumigated. The results are shown in table 5.

The data obtained with the low concentration of HCN show that the younger the eggs, the more difficult they were to kill; eggs 8 to 9 days old, just ready to hatch, were relatively easy to kill. Susceptibility of purple-scale eggs to fumigation increases greatly as the eggs increase in age from the 3- to 4-day period to the 4- to 5-day period. The percentage survival is about constant

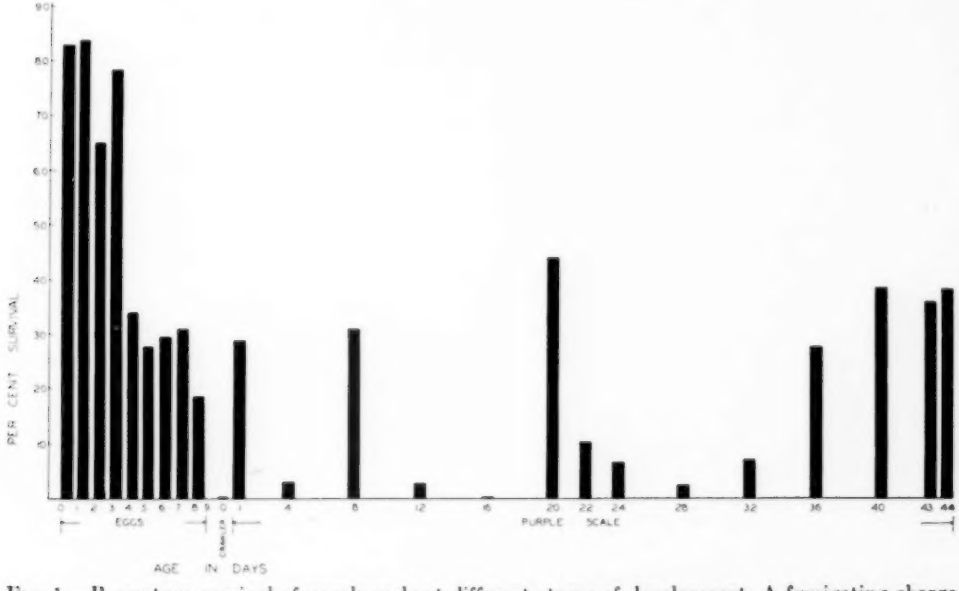

FIG. 1.—Percentage survival of purple scale at different stages of development. A fumigating charge of 0.37 mg. of HCN per L. was used, except for crawlers, which received 0.14 mg. HCN per L. Exposure, 40 minutes; temperature, 75°F.

up to and through the 3- to 4-day period and is practically constant again for eggs 4 to 5 days old to those 7 to 8 days old; but a sudden drop in survival is obtained between the ages of 3 to 4 days and 4 to 5 days. This corresponds to observations that, in field fumigation, the most posterior eggs are less likely to survive than the anterior eggs.

A series of experiments was also conducted to determine whether eggs under the scale are more difficult to kill by fumigation than eggs removed from under the female scale and fumigated in petri dishes. Eggs not more than 1 day old were used in all the tests, and the experiment was replicated 5 times. The eggs under the female scale and in the petri dishes were fumigated together in a 100-cu. ft. fumatorium at 75°F., with 0.36 mg. of HCN per liter. The number of eggs checked was 3,759. The percentage kill for eggs under the mother scales was 14.92 and for those in petri dishes, 15.48.

The results indicate that the scale covering does not protect the eggs from HCN in fumigation. The difference in the percentage hatch of eggs in these tests was 0.56, which is not significant. The lack of significant difference in results is interesting because the scale covering over the body of the purple scale is heavy, and at the time of the fumigations no young had hatched to break their emergence hole through the thin ventral covering at the posterior end of the scale.

EFFECT OF PRECONDITIONING EGGS.—Since it has been reported that purple scale eggs can be destroyed readily by cyanide gas fumigation, except in the winter months when the results are not so satisfactory (Woglum 1923), experiments were carried out to determine what effect the preconditioning of eggs at different temperatures might have on the results of fumigation with HCN.

Grapefruits infested with adult purple scale of known age, which had been producing eggs up to 1 day, were preconditioned at temperatures of 50°, 75°, and 90°F. for 3 to 4 hours just prior to fumigation. The fumigations were conducted in

a 100-cu. ft fumatorium, at 75°F. for 40 minutes, with 0.37 mg. of HCN per liter. During the fumigation, the fruits and insects preconditioned at 50°F. tended to rise in temperature while those preconditioned at 90° tended to drop; but the changes were not very great. Immediately after fumigation the eggs were removed from under the scale covering and placed in petri dishes until they hatched. The experiment was replicated six times. Infested fruits preconditioned at the different temperatures were fumigated together. The number of eggs checked was 3,382. Kills were as follows: 23.85 per cent of the eggs preconditioned at 50°F., 20.50 per cent of those preconditioned at 75°, and 40.50 per cent of those preconditioned at 90°.

The results show that the eggs preconditioned at 90° were more readily killed than those preconditioned at 50° or at 75°. There was no great difference between the kills by fumigation of eggs preconditioned at 50° and at 75°. It may be noted that this is the reverse of the results obtained by preconditioning the insects 22 or 43 days of age (Table 4).

A histogram, figure 1, was drawn from data given in the preceding pages, to allow a ready comparison of the susceptibility of purple scale eggs of different ages, crawlers, and scale insects of different ages to HCN fumigation. The rectangles in the histogram are comparable (except for the one representing the survival of crawlers), since the concentration of gas, time of exposure, and temperature are similar in all cases. The crawlers were exposed to a lower concentration of HCN. It may be observed (Fig. 1) that eggs less than 4 days old were the most difficult to kill, whereas eggs 5 days old or older were not so difficult to kill as the scale insects in some periods of development, notably, 20-day scales in the late second molt and mature scales 40 to 44 days of age. The crawlers or active young succumbed most readily to fumigation.

SUMMARY.—Purple scales in the crawler stage of development are most susceptible to fumigation with HCN. Other stages easily killed are those of early first and second molts, second instar, and those from just past the second molt through the period in which the main scale covering is laid down.

Purple scale eggs in the first half of their developmental period are more difficult to kill by HCN fumigation than any other stage in the development of the insect. Other stages difficult to kill are the eggs in the last half of their development, the recently settled insects, the late first molt, the late second molt, and the mature egg-laying insects.

No protective stupefaction was demonstrated in the purple scale under the conditions of these experiments.

Mature insects and insects just past the second molt, preconditioned at 50°F., were more easily killed than those preconditioned at 75°; while the latter, in turn, succumbed more readily than those preconditioned at 90°. On the other hand, young purple scale eggs preconditioned at 90°F. were more readily killed than eggs preconditioned at 50° or 75°.

Fumigation at 90°F. resulted in a higher mortality of mature purple scale than that at 75°. There was little difference in the mortality of purple scale just past the second molt, whether fumigated at 75° or at 90°F.—11-12-40.

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A Laboratory Method for Testing Fumigants: Results with Methyl Bromide Against the Firebrat

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Since the first report of the insecticidal use of methyl bromide by Le Goupil (1932) this fumigant has occupied a position of increasing importance. In February, 1939, it was officially approved for the treatment of nursery stock to be moved out of areas placed under quarantine because of the Japanese beetle. The historical uses and properties of methyl bromide have been adequately treated by Mackie (1938) and Fisk & Shepard (1938).

Laboratory determinations of the toxicity of methyl bromide to a number of insect species have been reported. Jones (1938) found the concentration required to kill 50 per cent of *Tribolium castaneum* Hbst. in 5 hours at 27°C. to be 6.13 milligrams per liter. Fisk & Shepard (1938) and Shepard & Buzicky (1939) have determined the median lethal concentrations of methyl bromide at 25°C. and 5 hours exposure for a large number of stored product insects. The firebrat, *Thermobia domestica* Pack., was used as the test insect for the investigation reported in this paper. Apparently no information has been published regarding the toxicity of methyl bromide to this important household pest.

The various methods that have been used in laboratory fumigation tests are reviewed by Jones (1933). The method described by Jones and later used in fumigation experiments with methyl bromide is based upon the introduction of the vapors of volatile fumigants into a partially evacuated fumigation flask, the concentration being measured by means of the depression of a mercury manometer. Other laboratory methods used in tests with methyl bromide are described by Fisk & Shepard (1938) and Shepard *et al.* (1937).

The principle of the method described in this paper is frequently used by chemists for exact measurement of small quantities of a liquid, and has been previously employed in insecticidal experiments as a means of calibrating the apparatus. It involves the use of specially prepared glass ampules containing a weighed amount of fumigant which is released in the flask by breaking the ampule.

Procedure.—A precise method of measuring the various concentrations of methyl bromide was employed throughout the experiment. Glass ampules with capillary necks from 40 to 110 mm. in length were drawn from glass tubing. These were carefully weighed, filled with methyl bromide, and reweighed. The filling was accomplished by immersing the capillary ends of the ampules in methyl bromide in a specially prepared side-necked test tube which was surrounded by solid carbon dioxide. The methyl bromide was forced into the ampules by first creating a partial vacuum with a water suction pump and then restoring atmospheric pressure within the tube. The filled ampules were drawn from the test tube with a wire hook and immediately placed, bulb downward, in a beaker containing small chips of solid carbon dioxide. The end of the capillary neck was then sealed with the flame from a micro-burner. It was found convenient to fill the ampules in lots of eight, the identification of each with respect to its original weight being retained by previous adjustment and measurement of the length of the capillary neck.

Glass erlenmeyer flasks of approximately 6.3 liters capacity were used in the fumigation tests. Each flask was closed with a 2-hole rubber stopper covered with *Duco* cement. Through one hole there was a glass tube containing a ground-glass stopcock; through the other a glass tube containing a rubber plug with a wire passed through its center. One end of the wire was bent into a loop for holding the ampule; to the other end was attached a handle. By pulling on the wire the ampule could be broken at the desired time. Through careful manipulation the capillary neck of the ampule could be bent against the side of the fumigation flask and broken off, thus liberating its contents in the upper part of the flask.

Only young adult firebrats exceeding 7 mm. in length were used in the tests. These were divided into subsamples of approximately 30 insects each and placed in

* Acknowledgment is made to Dr. C. H. Richardson for guidance in carrying on this work, and to Dr. I. B. Johns for suggestions regarding the method to be employed.

$2\frac{1}{4}$ by $\frac{3}{4}$ inch cylindrical cages, made of 16-mesh screen wire covered with cheesecloth. Each cage was suspended about one-half inch above the bottom of the flask by a thread. When the cage containing the insects and the ampule were in place a vacuum of approximately 4.5 cm. of mercury was drawn, the ampule broken, and atmospheric pressure restored within the flask as soon as the methyl bromide had completely evaporated. The flasks

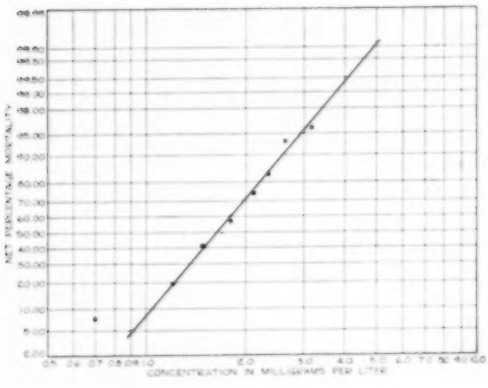

FIG. 1.—Toxicity of methyl bromide to *Thermobia domestica*. Temperature 30°C.; exposure 5 hours. The total number of insects treated was 133 for the lowest point, and varied from 283 to 410 for each of the other points. The point of lowest concentration was not considered in fitting the line.

were then allowed to stand in a constant-temperature cabinet at 30°C. for 5 hours.

At the end of the exposure period the insects were removed from the cages and placed in glass vessels containing food in a constant-temperature cabinet at 37°C. Examinations were made at the end of 24- and 72-hour periods. An insect was considered as dead if, at the end of the 72-hour period following its removal from the fumigation flask, it could not exhibit perceptible locomotion.

RESULTS.—The experimental data are plotted in figure 1 on logarithmic probability paper. The line was fitted to the points by the method of least mean squares (Bliss 1935). A chi-square value of 7.967 was obtained. The median lethal concentration of methyl bromide for the firebrat was calculated as 1.65 mg. per liter. Inasmuch as a few deaths occurred in the check samples the net percentage mortality was determined from Abbott's formula (Abbott 1925).

The methyl bromide was found to manifest a delayed action except in those cases where concentrations were used in excess of that required to kill 100 per cent. Death usually occurred within a period of 12 to 24 hours after the insect had been removed from the fumigation flask, however, a few additional deaths frequently occurred within the 72-hour observation period. Many of the killed insects were observed to be firmly stuck to the glass surface by a regurgitated fluid.

DISCUSSION.—The method of fumigation described above is of particular value in those cases where a fumigant of low boiling point is to be used, and where the amount to be measured is extremely small. Other advantages are its accuracy and its relative simplicity. A balance which weighed to 0.1 of a milligram was used throughout the work reported in this paper. The apparatus employed was of the simplest type, and the method of measuring the fumigant was independent of temperature or other fluctuating conditions for which corrections must usually be made. The use of carefully weighed ampules for measuring the desired quantity of fumigant might give the impression of being a tedious method; however, the authors found this not to be true. The time required could be reduced by the use of some form of rapid-weighing balance. Although it is not possible to determine in advance the exact quantity to be measured, the approximate amount may be readily obtained by varying the size of the ampules. As soon as the desired range of concentrations is determined the ampules can be made up in large quantities and those of the correct size selected for filling.

The method of measuring quantities of fumigants by means of weighed ampules could perhaps be used with mixed gases. If the materials to be used would not react chemically and would form a homogeneous solution they could be mixed in the desired ratio before being drawn into the ampule. If mixing in the liquid state was not advisable separate ampules could be prepared for the desired concentrations of the different materials.

Methyl bromide is more toxic to the firebrat than to any of the insect species so far investigated when comparisons are made with the concentrations required to kill 50 per cent. The median lethal concentrations of methyl bromide reported for species of Coleoptera vary from 4.0 mg. per liter for the adult rice weevil (*Sitophi-*

lus oryzae) to 17.5 mg. per liter for the larva of the black carpet beetle (*Attagenus piceus*). The median lethal concentrations of methyl bromide reported for species of Lepidoptera are 3.1 and 5.0 mg. per liter for the adult and larva, respectively, of the Indian-meal moth (*Plodia interpunctella*), and 7.0 mg. for the larva of the webing clothes moth, *Tineola biselliella*.

SUMMARY.—A new method of laboratory fumigation is described. It employs the use of carefully weighed glass ampules for measuring exact quantities of the fumigant. It is adaptable for mixtures of gases.

The median lethal concentration of methyl bromide for *Thermobia domestica* was determined as 1.65 milligrams per liter by this method.—8-12-40.

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Methyl Bromide Fumigation for Destruction of the Strawberry Crown Borer[1,2]

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The strawberry crown borer, *Tyloderma fragariae* (Riley), is a serious pest of strawberries in the area including western Kentucky, southern Illinois, Missouri, Arkansas, and Tennessee. The insect is the most destructive strawberry pest found in Kentucky and during the past 40 years has caused the practical abandonment of berry growing in at least two sections of the state. At present, the worst infestations are centered in the vicinities of Paducah and Louisville, both important berry producing areas.

During the past 4 years, the writer has made a study of crown borer biology and control (Ritcher, 1938, 1939 and 1940). Cultural methods of control now recommended include the use of certified, crown-borer-free plants; early digging and cleaning of plants for new plantings before egg-laying begins; destruction of old patches and of wild hosts, such as cinquefoil; and the placing of new fields at 350 or more yards from a source of infestation.

In recent years, Mackie (1936), Donohoe (1939), Donohoe *et al.* (1940), Hawkins (1939), Latta (1940), Shepherd and Buzicky (1939) and others have developed methods for the use of methyl bromide fumigation for the solution of a number of insect problems. Several of these are remarkable in that they involve the destruction of insects within living plant tissue. An investigation of the use of methyl bromide to kill strawberry crown borer in plants to be used for setting new patches was begun here in the spring of 1940.

METHODS.—The main purpose of this investigation was to determine the dosage, exposure time and temperature necessary to give a complete kill of all stages of the crown borer without causing plant injury. The study was restricted to fumigation at atmospheric pressure.

A 25-cu. ft. fumigation chamber was used in the study. Plants and crown borers were placed in a bushel basket or shipping crate and counts were made only of material from the middle layer of the container. Methyl bromide was measured

[1] The investigation reported in this paper is in connection with a project of the Kentucky Agricultural Experiment Station and is published by permission of the Director.

[2] Early publication of this paper has been assured by payment of the costs of printing.

from the cylinder by means of a gauge[3] and introduced near the top of the chamber over a 10-inch, flat, enameled evaporating pan. A fan for distributing the fumigant was run for 10 minutes after the methyl bromide was introduced and again to air the chamber at the end of the fumigation period.

Heavily infested plants from either Paducah or Louisville were used for testing the toxicity of methyl bromide to immature stages of the crown borer. Plants fumigated in April, May, and June contained many eggs and larvae. Those fumigated in July contained, in addition, numerous prepupae, pupae, and adults (Table 1). The infested plants used in these tests were usually 2 or 3 years old and had crowns much larger and woodier than is the case with 1-year runner plants commonly used to set new patches.

Table 1.—Seasonal development of strawberry crown borer at Buechel, Kentucky, 1940.

Date	Plants Examined	Borer Population per 100 Plants				
		Larvae	Prepupae	Pupae	Adults	Adults emerged
July 13	23	57.2	17.6	44	0*	0
July 19	50	26	4	12	8	0
July 26	21	23.5	4.7	14.1	18.8	23.5
August 3	100	28	0	7	11	45
August 13	50	54	0	6	12	42
August 22	100	17	0	0	5	42
September 3	100	9	1	3	2	52
October 12	100	11	2	2	1	—
October 24	100	5	0	0	0	—
November 20	100	0	0	2	0	—
December 11	200	0	0	0	0.5	—

* One newly transformed adult found inside infested plant July 12.

After fumigation and airing, plants were re-planted in the field or set out in the greenhouse or insectary. In the early months of the work, counts were delayed until enough time had elapsed for eggs to hatch. Later on, when few eggs were present, counts were made within as early as 5 days after treatment. The mortalities given in table 2 are only approximate since they were determined by comparing the survival in each treated lot with the population present in untreated lots examined at about the time treatment was made.

Adult crown borers used in the tests were secured from the soil around berry plants. Those from western Kentucky were collected by W. D. Armstrong, Horticulturist, and mailed packed in ice. Adults were kept in excellent condition in the laboratory by confining them in jelly glasses half filled with moist sand. Several cleaned and trimmed berry plants were set in the sand to provide food and a place for oviposition. Adults to be fumigated were placed in a handful of moist dirt, wrapped in a piece of cheesecloth, and inserted in the center of the test crate. After fumigation, adults were sifted out and kept for observation in jelly glasses prepared in the manner of those described.

Eggs for fumigation tests were secured by allowing females to oviposit in 1-year plants. Certain jars containing a number of gravid females were set aside for this purpose and the plants containing eggs were removed three times a week and fresh plants added. Plants containing eggs were placed in the center of the test crate or basket of infested plants. After fumigation and airing, eggs were dissected out with a needle, under a binocular microscope. Fumigated eggs and suitable checks were incubated on moist towel paper in salve boxes at room temperature.

To determine the effect of methyl bromide on berry plants, both dormant and non-dormant plants were fumigated. Samples of fumigated plants were set out on the Station farm or in benches in the insectary, and observations made on their survival and rate of growth for a period of several months. Also, during the winter of 1940–41, a number of lots of plants dug fresh from the field and plants which had been held in storage at 34 degrees F. were fumigated and set out in pots in the greenhouse for observation.

TOXICITY TO LARVAE.—Fumigation tests with berry plants containing crown-borer larvae were made using 2 pounds of

[3] Made by the Arrow Products Company.

Table 2.—Methyl bromide fumigation of crown borer-infested strawberry plants and adult crown borers at atmospheric pressure.

TEST NO.	TEMP. RANGE, °F.	NO. OF PLANTS	LIVE BORERS	DAYS HELD	PER CENT MORTALITY	NO. OF ADULTS	PER CENT MORTALITY
		2 Pounds per 1,000 Cubic Feet for 2 Hours					
40-1400	67–74	50	0	7	100	—	—
40-14RR	68–72	50	6	6	83.3	20	100
Check	—	50	36	—	—	—	—
40-14PP	69–73	50	0	6	100	20	100
40-14MM	71–76	50	7	8	69.4	20	100
14-14LL	72–75	100	8	8	82.6	—	—
Check	—	100	46	—	—	—	—
40-14QQ	72–75	100	4	7	94.2	20	100
40-14UU	74–75	—	—	—	—	20	100
40-14VV	75–82	100	8	8	63.6	—	—
40-14TT	75–85	50	1	10	97.3	20	100
Check	—	100	22	—	—	—	—
		2½ Pounds per 1,000 Cubic Feet for 2 Hours					
40-14D	62–64	50	0	14	100	20	100
40-14B	68–72	30	1	17	96	10	100
40-14E	74–77	70	0	20	100	10	100
Check	—	50	31	—	—	—	—
40-14C	75–78	20	0	16	100	20	100
40-14A	76–78	50	1	23	96	10	100
Check	—	27	32	—	—	—	—
40-14I	76–80	50	3	7	88	10	100
Check	—	38	20	—	—	—	—
40-14F	80–82	50	0	12	100	10	100
		3 Pounds per 1,000 Cubic Feet for 2 Hours					
40-14NN	61–70	50	1	7	97	—	—
Check	—	50	36	—	—	—	—
40-14Q	64–69	50	0	7	100	—	—
40-14II	68–74	—	—	—	—	25	100
Check	—	100	46	—	—	—	—
40-14DD	71–78	50	0	12	100	—	—
Check	—	21	15	—	—	—	—
40-14Y	72–76	50	0	7	100	—	—
40-14Z	74–76	50	0	7	100	—	—
Check	—	50	25	—	—	—	—
40-14CC	75–80	50	0	9	100	—	—
40-14AA	79–84	100	0	11	100	40	100
40-14N	80–85	50	0	6	100	—	—
		3 Pounds per 1,000 Cubic Feet for 3 Hours					
40-14WW	61–69	100	1	12	95.5	—	—
Check	—	100	22	—	—	—	—
40-14P	63–70	100	2	6	94	—	—
40-14SS	68–80	50	2	11	94.4	—	—
Check	—	50	36	—	—	—	—
40-14M	70–73	50	0	6	100	—	—
40-14JJ	70–75	100	0	11	100	—	—
Check	—	100	46	—	—	—	—
40-14FF	73–80	50	0	10	100	—	—
40-14EE	74–80	50	0	11	100	—	—
Check	—	21	15	—	—	—	—
40-14BB	76–82	50	0	12	100	—	—
Check	—	50	25	—	—	—	—
40-14O	79–82	50	0	7	100	—	—
		3 Pounds per 1,000 Cubic Feet for ¼ Hours					
40-14V	63–72	75	0	9	100	—	—
Check	—	28	27	—	—	—	—
40-14X	66–70	50	0	6	100	—	—
40-14K	69–73	50	0	5	100	—	—
40-14J	72–80	150	0	6	100	—	—
Check	—	27	32	—	—	—	—
40-14L	73–	50	0	7	100	—	—
40-14W	77–82	50	0	7	100	—	—

methyl bromide per 1,000 cubic feet for a 2-hour period; 2½ pounds per 1,000 cubic feet for a 2-hour period; 3 pounds per 1,000 cubic feet for a 2-hour period; 3 pounds per 1,000 cubic feet for a 3-hour period; and 3 pounds per 1,000 cubic feet for a 4-hour period (Table 2). With a 2-pound dosage per 1,000 cubic feet for a 2-hour period, mortalities ranged from 63.6 to 100 per cent. The 3-pound dosage per 1,000 cubic feet for a 4-hour period was the only dosage that gave a complete kill in all the tests run at that level. However, there was also complete mortality with 3 pounds per 1,000 cubic feet for both 2 and 3 hours, where the minimum temperature did not fall below 70 degrees F.

Fumigated larvae exhibited the delayed mortality characteristic of other insects when treated with methyl bromide. There was considerable activity after fumigation followed by a period of inactivity. Dead larvae became distended and finally turned black.

TOXICITY TO ADULTS.—A number of fumigation tests with adult strawberry crown borers were made with 2 and 2½ pounds of methyl bromide per 1,000 cubic feet for a 2-hour period, and with 3 pounds per 1,000 cubic feet for a 2-hour period (Table 2). In all cases complete mortality was secured. Apparently the adult is easier to kill than any other stage of the insect.

Fumigated adults exhibited great activity for a few hours. All of them moved their legs and antennae rapidly but with poor coordination. A few were able to crawl a short distance but the majority lay where they were placed. No feeding

Table 3.—Methyl bromide fumigation at atmospheric pressure of strawberry plants containing crown borer eggs.

TEST NO.	TEMP. RANGE, °F.	NO. OF EGGS	DATE LAID (1940)	DATE FUMIGATED (1940)	DAYS HELD	PER CENT MORTALITY
			2 Pounds per 1,000 Cubic Feet for 2 Hours			
40-14RR	68–72	4	8/12	8/14	26	100
Check	—	15	8/12	—	9	0
40-14PP	69–73	20	8/8	8/10	16	100
40-14LL	72–75	21	8/4	8/6	15	100
Check	—	20	8/4	—	10	5
40-14UU	74–75	11	8/18	8/20	20	90.9
40-14TT	75–85	2	8/14	8/16	10	100
			3 Pounds per 1,000 Cubic Feet for 2 Hours			
40-14NN	61–70	33	8/6	8/8	13	100
40-14II	68–74	25	7/30	8/1	20	100
40-14KK	69–76	44	8/2	8/5	16	100
40-14DD	71–78	33	7/23	7/25	14	100
Check	—	15	7/26	—	8	40
40-14Y	72–76	19	7/16	7/17	14	100
40-14HH	73–80	60	7/29	7/30	16	100
Check	—	15	7/30	—	10	7
40-14CC	75–80	55	7/22	7/23	16	100
40-14GG	75–82	32	7/26	7/29	16	100
40-14AA	79–84	27	7/18	7/19	20	100
Check	—	15	7/21	—	9	20
			3 Pounds per 1,000 Cubic Feet for 4 Hours			
Check	—	8	6/25	—	12	12.5
40-14R	60–70	34	6/30	7/3	12	100
40-14V	63–72	51	7/9	7/13	14	100
Check	—	15	7/9	—	11	0
40-14U	71–73	36	7/7	7/8	19	100
40-14S	73–76	22	7/2	7/3	13	100
40-14TA	75–80	15	6/28	7/5	10	100
40-14TB	75–80	17	7/4	7/5	14	100
Check	—	10	6/28	—	17	20
40-14W	77–82	40	7/14	7/15	15	100
Check	—	16	7/16	—	11	7

whatever occurred after fumigation although death was sometimes delayed as long as 5 days after treatment.

TOXICITY TO EGGS.—Crown borer eggs were fumigated with methyl bromide at the rate of 2 pounds per 1,000 cubic feet for a 2-hour period; 3 pounds per 1,000 cubic feet for a 2-hour period; and 3 pounds per 1,000 cubic feet for a 4-hour period (Table 3). The only survival noted occurred in one test with 2 pounds per 1,000 cubic feet for a 2-hour period. Apparently the eggs in berry plants are easier to kill than the larvae. The location of some larvae in the centers of plant crowns may account for this apparent difference in susceptibility.

TOXICITY TO PLANTS.—Methyl bromide fumigation of strawberry plants is not new, having been tested several years ago by federal entomologists for the destruction of Japanese beetle larvae. Hawkins (1939) reported a method of fumigating strawberry plants on a commercial basis. A dosage of 3 pounds per 1,000 cubic feet for a 4-hour period at a minimum temperature of 60 degrees F. is suggested in the Bureau of Entomology and Plant Quarantine administrative instructions (Rohwer 1939). Haller (1939) presented data on the growth of Gem and Premier strawberry plants fumigated in the dormant condition with 3 pounds of methyl bromide for a 4-hour period at 60 degrees F. He reported some injury to Gem plants fumigated in December and no injury to two lots of Premier plants, one fumigated March 21 and one April 22.

In May, 1940, the writer fumigated three lots of dormant berry plants with 2½ pounds of methyl bromide per 1,000 cubic feet for a 2-hour period at 76–78 degrees, 68–72 degrees and 75–78 degrees F., respectively. Plants set out in the field grew normally during the several months of observation. In December, 1940, four lots of dormant berry plants were fumigated with 3 pounds of methyl bromide per 1,000 cubic feet for a 2-hour period at temperatures of 64–68 degrees, 68–78 degrees, 73–79 degrees, and 87–92 degrees F. The first three lots contained Aroma, Premier and Blakemore plants while the lot at 87–92 degrees contained only Premier and Blakemore. Growth of plants from the first three lots, in the greenhouse, was normal compared to that of check plants. In the lot fumigated at 87–92 degrees F., the blossom buds were killed on part of the Premier plants and double crowns developed. On Blakemore, fumigated at the same temperature, the blossom buds were not killed and plant growth was stimulated. Premier plants fumigated on November 29 with 3 pounds of methyl bromide per 1,000 cubic feet for a 3-hour period at 78–91 degrees and Premier and Blakemore plants fumigated December 3 with 3 pounds per 1,000 cubic feet for a 4-hour period at 66–80 degrees had blossom buds killed, and two growing points developed in many instances.

Non-dormant plants were not harmed by fumigation with 2 pounds of methyl bromide per 1,000 cubic feet for a 2-hour period. Non-dormant plants were usually severely injured by fumigation with 3 pounds per 1,000 cubic feet for either a 3-hour or a 4-hour period.

DISCUSSION.—The crown borer winters almost always in the adult stage, hibernating on the surface of the soil under litter, or in the soil of infested berry patches. Egg laying in western Kentucky begins early in March and in eastern Kentucky about March 15 but relatively few eggs are laid before April 15. Eggs laid early in the spring are very slow in hatching, requiring an average of about 24 days for eggs laid in April. This means that no larvae are present in berry plants until early April.

New strawberry patches are always set in the spring, the best patches resulting when plants are set early in March. Some patches, however, are set as late as the last of April. Since crown borer egg laying begins in March, it has been recommended, in general, that growers dig plants for new patches before March 1. By cleaning and washing such plants it is possible to get rid of any adults that may be present, but this is a time-consuming process and uncertain of satisfactory result in the hands of growers.

For growers to take advantage of methyl bromide fumigation of berry plants for new patches, it would be necessary to set up fumigation chambers in each of the areas where crown borer is a problem. A dosage of 3 pounds of methyl bromide per 1,000 cubic feet for a 2-hour period at a temperature of 70 degrees F. or above should be sufficient for plants fumigated before April 1, since only adults and eggs would be present at that time in Kentucky.

SUMMARY.—A study was made of methyl bromide fumigation at atmospheric pressure as a means for destroying all stages of the strawberry crown borer in plants to be used for setting new patches. Complete mortality of adults was secured with a minimum dosage of 2 pounds of methyl bromide per 1,000 cubic feet for a 2-hour period within a temperature range of from 68 to 85 degrees F. Complete mortality of eggs resulted with a minimum dosage of 3 pounds per 1,000 cubic feet for a 2-hour period within a temperature range of 61 to 84 degrees F. Mortality of larvae was complete at a minimum dosage of 3 pounds of methyl bromide per 1,000 cubic feet for a 2-hour period at temperatures above 70 degrees F. No injury to dormant plants resulted from a 2-hour exposure to 3 pounds of methyl bromide per 1,000 cubic feet at temperatures below 80 degrees F. Non-dormant plants were uninjured by a 2-hour exposure to 2 pounds of fumigant per 1,000 cubic feet but were severely injured by 3- and 4-hours exposure to 3 pounds of methyl bromide per 1,000 cubic feet. Fumigation of dormant strawberry plants before April 1 with a dosage of 3 pounds of methyl bromide per 1,000 cubic feet of space for a 2-hour period at a minimum temperature of 70 degrees F. is suggested to free strawberry plants from crown borer.—1-11-41.

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Derris Residue on Marketable Cabbage

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Derris has found one of its principal uses in the control of certain truck-crop insects, particularly the imported cabbage worm commonly found infesting cabbage, cauliflower, and other cole crops. No report has been published which shows to what extent the derris may be present when the treated crop reaches the consuming public, although Roark has voiced an opinion (Ambrose & Haag 1938) based on studies of arsenical residues by Smith and coworkers (1937) that cabbage probably would not contain more than 25 parts of derris per million at harvest.

During the harvest season of 1938 an opportunity arose to study derris residues on cabbage from the experimental plots of the truck-crop insect field station of the Bureau of Entomology and Plant Quarantine, at Charleston, S. C.* The analyses were made on the ground so that no residue would be lost by unnecessary handling or in shipment of the cabbage heads.

The cabbage heads selected for analysis were taken from the central two rows of

* The author acknowledges his indebtedness to W. J. Reid, Jr., of this Bureau for the dusting and collecting of cabbages, and to B. L. Wade, of the Bureau of Plant Industry, for the use of laboratory facilities.

each plot to avoid, as much as possible, contamination from adjoining plots which had received different treatments. Each cabbage was prepared by removing all the wrapper leaves and three leaves from the head. Each leaf was washed thoroughly with chloroform, and the washings of all the leaves from a single cabbage were combined. The chloroform was then filtered and evaporated to dryness and the residue redissolved in hot acetone. This acetone solution was placed in a refrigerator for about 30 minutes to chill out the natural wax dissolved from the cabbage leaves, which otherwise would interfere with the final colorimetric determination. The solution was then filtered and the filtrate made up to a volume of 25 cc. The final determination was made by taking a 2-cc. aliquot of this solution and proceeding with the Goodhue (1936) colorimetric determination, which is believed to be a measure of rotenone plus deguelin. However, standards were prepared by extracting a known quantity of derris root actually used for dusting the experimental plots. The color intensity of known and unknown samples was determined in a photoelectric photometer, and calculated to equivalent derris.†

Several dusting schedules were used at the station this year, and the one expected to give the largest amount of residue, as judged by the quantity of derris applied, was chosen for the analytical work.

The variety of cabbage used was the Charleston Wakefield. The plants averaged 20 to 24 inches wide at harvest, and weighed on an average 2.1 pounds. They were planted 15 inches apart and the rows were 3 feet on center. There were therefore approximately 11,600 plants per acre.

A dust containing 25 per cent derris (the derris root contained 4.1 per cent rotenone and 15.1 per cent chloroform extract) and 75 per cent clay was applied at the rate of approximately 20 pounds per acre per application, and the six replicate plots receiving this treatment were dusted five times at 7-day intervals beginning April 4. Weighing of the dusters showed that the plants actually received the equivalent of 95 pounds of the 1 per cent rotenone mixture during the five dustings.

† To date only rotenone and deguelin have been found to respond to the color test used. Since these materials decompose when exposed to light and air, the method of analysis does not in the strict sense measure the residue present, except when made immediately after the dusting.

At the present time a 0.75 per cent rotenone dust applied at the rate of 20 pounds per acre is recommended for commercial use, and generally there are only three, or at most four, applications during the growing season. During the past six seasons records show that out of a total of 40 fields, 33 of which were growers' plantings and entirely attended by the grower, only 2 received as many as five applications of derris dust of any strength, and only 4 fields received as many as four applications. According to these data and other information furnished by the truck-crop field station, by the present practice, not more than 10 per cent of the cabbage grown in this area is likely to receive as much derris per acre as was applied on the plots sampled for this work.

The plots were sampled on the morning after the fifth dusting, 8 heads being taken from each plot, giving a total of 48 heads which were analyzed separately. After the heads had been cut, all loose leaves except the four wrapper leaves were discarded to make the cabbages conform to the U. S. No. 1 grade.

Although statistical analysis of the results showed that the means for the various replicate plots differed significantly from one another, the odds being about 49:1, the entire 48 analyses formed a fairly normal distribution, and for the purpose of this paper they have been considered together. The results ranged from 0.04 to 0.43 grain of derris per pound, with a mean of 0.225 and a standard deviation of 0.081 grain per pound. From these results it may be calculated that, among the 11,600 heads on the acre, one head might be encountered that would contain 0.525 grain of derris per pound, equivalent to 73 parts per million.

That the residues resulting from the dusting schedules outlined are further subject to drastic reduction by moderate rinsing with water was also determined. Three of the plots were sampled again on the morning after 0.6 inch of rain had fallen, and treated for analysis exactly as already described. The 12 heads analyzed showed residues ranging from 0.008 to 0.059, with an average of 0.025 and a standard deviation of 0.015 grain per pound. This is much less than that present before the rain, and indicates what might be accomplished by merely rinsing the cabbage before using it. However, it is

probably commoner practice to strip off the wrapper leaves before use. Consequently, 12 heads of the cabbage that had been rained upon were stripped of three of the four wrapper leaves before being analyzed. The residues found ranged from 0.003 to 0.033, with an average of 0.013 and a standard deviation of 0.009 grain per pound. Again the residue is reduced (odds of 19:1).

To obtain some information on the deket as U. S. No. 1 green heads, containing seven instead of four wrapper leaves, four such heads were analyzed. The residues found ranged from 0.21 to 0.43, with an average of 0.34 and a standard deviation of 0.10 grain per pound. This is significantly larger (odds of 80:1) than the residue on similar heads of U. S. No. 1 grade, and is undoubtedly due merely to the extra surface.

Table 1 summarizes the results given

Table 1.—Average derris residues found on heads of cabbage of different grades given either one or five dustings and sampled at different times.

Grade	Dustings at 5 Pounds per Acre	Time of Sampling	Heads Analyzed	Average Derris Residue		
				Grains per lb.	Mg. per head*	Ppm.*
U. S. No. 1	5	Before rain	48	0.225±0.012	34.9	36.5
U. S. No. 1	5	After rain	12	0.025±0.0045	4.0	3.6
U. S. No. 1 stripped	5	After rain	12	0.013±0.0025	1.7	1.9
U. S. No. 1	1	Immediately	11	0.162±0.012	26.0	23.2
U. S. No. 1 green	5	Before rain	4	0.34±0.05	54.5	48.6

* These averages were figured from the individual heads. Their coefficient of variation will be about the same as for the averages given in grains per pound.

composition and weathering of the derris dust, some untreated cabbages were given a single application of the 1 per cent rotenone mixture at the rate of 20 pounds per acre. Eleven U. S. No. 1 heads were collected immediately after dusting and analyzed. The residue ranged from 0.11 to 0.23, with an average of 0.16 and a standard deviation of 0.040 grain per pound. On the basis of 20 pounds of dust per acre containing 11,600 heads (0.20 gram of derris per head) only 13 per cent of the dust adhered. Results previously given indicate a build-up by five applications (0.98 gram of derris per head) to only 0.225 grain per pound, 3 per cent of the total applied. It is impossible to say how much of the loss is to be ascribed to removal by rain or wind and how much to decomposition.

Because some cabbages are sent to market as U. S. No. 1 green heads, containing seven instead of four wrapper leaves, four such heads were analyzed. The residues found ranged from 0.21 to 0.43, with an average of 0.34 and a standard deviation of 0.10 grain per pound. This is significantly larger (odds of 80:1) than the residue on similar heads of U. S. No. 1 grade, and is undoubtedly due merely to the extra surface.

Table 1 summarizes the results given for all the experiments. In considering these results, the various comparisons must, of course, be viewed with due regard to the standard errors involved.

SUMMARY.—Analyses have been made of the derris residues on marketable heads of cabbage, both U. S. No. 1 and U. S. No. 1 green, which were dusted at 7-day intervals with five applications of a derris plus clay mixture containing 1 per cent rotenone. The effect of rain on the residue, the relative amounts of residue on three wrapper leaves, and the quantity of derris residue resulting from a single application have also been determined. Statistical calculations show that, among 11,600 heads from a single acre, one U. S. No. 1 head might be encountered that would contain 73 parts per million of derris (0.525 grain per pound).—6-23-39.

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Methyl Bromide as a Fumigant for Pests of Ornamental Plants[1]

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Along the Gulf coast the year-round mild climate has favored the development of an industry engaged in producing ornamental potted and outdoor plants. A mild winter climate makes expensive, tightly constructed greenhouses unnecessary, and consequently many greenhouses in the region cannot be fumigated. Similarly, the climate has favored the rapid development of various pests, some being able to reproduce almost continuously throughout the year.

In experimental work with methyl bromide against the white-fringed beetle, *Pantomorus leucoloma* (Boh.), and the congeneric species *P. peregrinus* Buch., dosages sufficient to kill larvae in small soil masses also eliminated some species of such foliage pests as scales, mealybugs, and whiteflies, as well as the common red spider.

Following these general observations preliminary experiments were conducted to determine whether smaller dosages would produce complete mortality or give control of some common ornamental pests in New Orleans without injuring the plants. No attempt was made to determine the minimum dosages and exposures required for complete kills. Although the experiments are too limited to give conclusive results, they may interest those concerned with these pests.

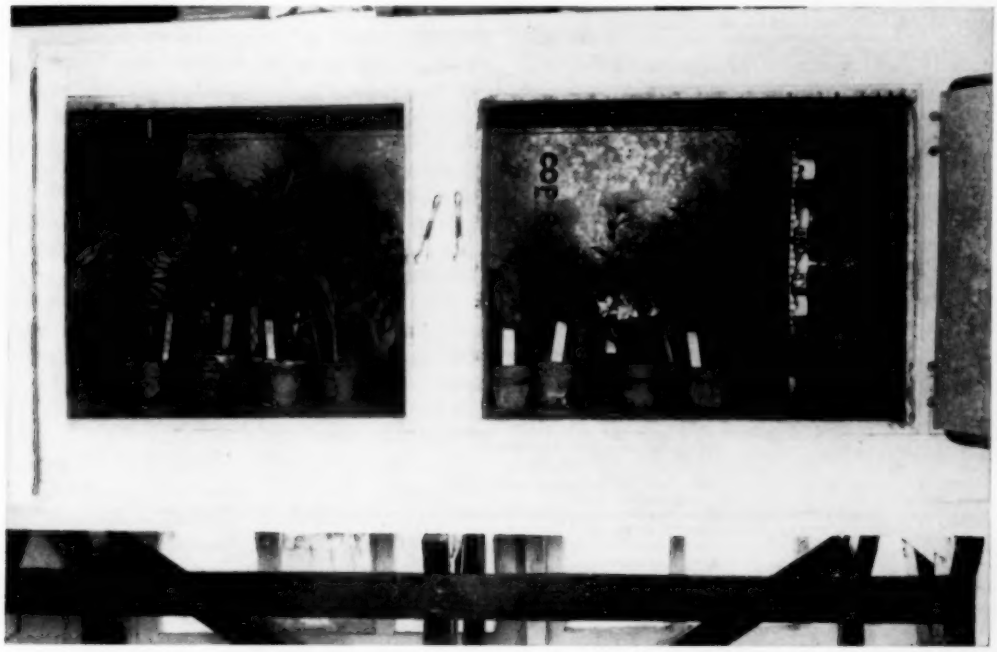

Fig. 1.—Interior view of fumatorium showing potted plants in place for fumigation.

Equipment and Procedure.—The fumigation equipment consisted of a metal-lined chamber (Fig. 1) having a capacity of 25 cu. ft. and a floor area of 12.5 sq. ft. The seams were made tight by soldering, and the walls well insulated with a 3-inch layer of bagasse board. In the chamber were an electric fan for circu-

[1] Publication of this paper has been secured by payment of the costs of printing.
[2] The work reported in this paper was done under the direction of Dr. Lon A. Hawkins ,Division of Control Investigations.

lating the fumigant and an electric heater, controlled by a thermostat, for governing the temperature. On one side of the fumigation chamber were two hinged doors which when closed fitted against gaskets. The liquid methyl bromide was introduced through a tubular opening in the fumigant was introduced. The insects tested, host plants, and experimental conditions are given in table 1.

RESULTS.—In all tests the mortality was complete. Observations made after treatment showed that no subsequent infestations developed on the plants. None

Table 1.—Atmospheric fumigation tests with methyl bromide against various insects attacking ornamental plants in New Orleans, La.

INSECT	HOST PLANT	POUNDS PER 1,000 CU. FT.	EXPOSURE, HOURS	TEMPERATURE	INSECTS EXAMINED	PERIOD FREE FROM INFESTATION
Chrysomphalus aonidum (L.)*, Florida red scale	*Ficus elastica*	1	3	89.0°F.	247	32 days
	Chrysalidocarpus (Areca) lutescens	½	4	90.5°	607	27
	Pandanus veitchi					
Chrysomphalus bifasciculensis Ferris*	*Aspidistra lurida*	½	4	86.0°	150	90
Diaspis echinocacti (Bouche)*, cactus scale	*Zygocactus truncatus*	1	4	84.0°	100	37
Fiorinia theae Green,* thea scale	*Camellia japonica*	½	4	90.5°	331	20
		½	4	90.5°	500	30
Pinnaspis aspidistrae (Sign.)*, fern scale	*Nephrolepis exaltata bostoniensis* (Boston fern)	½	4	86.5°	134	18
Lepidosaphes camelliae Hoke,* camellia scale	*Camellia japonica*	½	4	90.5°	787	30
	Camellia sasanqua					
Saissetia hemispherica (Targ.), hemispherical scale	Hibiscus	½	5	93.0°	1,347	30
Ericoccus azalea Comst., azalea scale	Azalea	½	4	84.5°	500	30
Pseudococcus adonidum (L.), long-tailed mealybug	*Codiaeum* (corkscrew croton)	1	4	89.5°	500	43
	Codiaeum variegatum var. *punctatum* (punctate croton)					
	Dracaena fragans var. *massangeana*					
	Dracaena (M. Story)					
	Pothos wilcoxii					
	Chrysalidocarpus (Areca) lutescens	½	4	86.0°	597	40
	Codiaeum (corkscrew croton)					
	Codiaeum variegatum var. *punctatum* (punctate croton)					
	Dracaena fragans var. *massangeana*					
	Phoenix roebelinii					
	Pothos wilcoxii					
	Chrysanthemum					
Dialeurodes citri Ashm., citrus whitefly	*Ficus nitida*	½	4	87.0°	0	40
	Gardenia					
	Ligustrum					
	Pittosporum					
Tetranychus bimaculatus Harvey, common red spider	*Chrysalidocarpus (Areca) lutescens*	½	4	87.5°	527	33
	Livistona chinesis					

* Identified by H. Morrison, Bureau of Entomology and Plant Quarantine, Division of Insect Identification.

top wall of the chamber into a small pan directly above the fan.

Infested plants were placed in the chamber and the heater and fan turned on, the fan being run at slow speed to avoid injuring the plants. After about 2 hours had been allowed for the insects to become adjusted to the temperature, the

of the plants except *Hibiscus*, *Dracaena* (M. Story), *Pothos wilcoxii*, and *Chrysanthemum* was affected by the fumigant. All the leaves except the terminals of *Hibiscus* dropped, but 3 months after treatment the plants had recovered. The lower leaves of *Chrysanthemum* browned. —10-23-40.

Toxicity to the Housefly of the Noncrystalline Constituents of Roots of *Tephrosia virginiana*

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It has become customary to express the quality of rotenone-containing materials in terms of the rotenone and total-extractive content as determined by chemical means. The insecticidal significance of the rotenone content is definite since it has a fixed known toxicity, but the insecticidal action of the extractives other than rotenone may vary considerably depending on on the source of material or the species of plant. The potential importance of *Tephrosia virginiana* (L.)[1] as a source of this group of insecticides has stimulated interest in the correlation of the chemical nature of the constituents with their toxicological action. Goodhue & Haller (1940) have found that the noncrystalline portion of the extractives can be conveniently divided into three fractions, an alkali-soluble portion, a neutral resin, and an oil. They obtained considerable information about the chemical nature of each fraction and isolated three compounds of unknown structure. To determine which fractions contained the insecticidal material, toxicity tests with these materials in comparison with rotenone have been conducted against the housefly, *Musca domestica* L.

PREPARATION OF MATERIALS.—Ten pounds of a variety of *Tephrosia virginiana* root that has been improved by selective breeding[2] was exhaustively extracted by percolation with chloroform. The chloroform was removed and the residue was taken up in ether, from which part of the rotenone was removed by crystallization. The alkali-soluble portion was isolated by extraction of the ether solution with 5-per cent potassium hydroxide solution and recovered by acidification of the alkaline solution. The remainder of the rotenone was then removed by crystallization from a carbon tetrachloride solution of the resin insoluble in alkali. Thus freed of rotenone, this portion was divided into a neutral resin and an oil by partition between 90 per cent acetic acid and petroleum ether. The oil is more soluble in the petroleum ether. A small amount of a crystalline compound that melted at 76 degrees C. was isolated from the alkali-soluble portion, and two compounds, one melting at 125 degrees C. ($C_{22}H_{24}O_4$) and another melting at 131 degrees C. ($C_{21}H_{22}O_4$), were isolated from the neutral resin, as described in the paper by Goodhue and Haller (1940).

The three noncrystalline fractions were dissolved at the rate of 2.0 mg. per cc. in both acetone and refined kerosene containing 5 per cent of cyclohexanone. The refined-kerosene solutions of the alkali-soluble portion and the neutral resin were turbid. Some of the material settled after standing, but it could be suspended easily by shaking. A standard rotenone solution containing 0.5 mg. per cc. was prepared in both solvents. Solutions containing 2.0 mg. per cc. in acetone were made from the two crystalline compounds melting at 125 and 131 degrees C. Not enough of the compound melting at 76 degrees C was available for testing. The more dilute solutions used in some of the tests were made by dilution with the respective solvents.

TESTS OF TOXICITY.—Laboratory-bred houseflies were sprayed by the turntable method (Campbell & Sullivan 1938) with three concentrations of the solutions of rotenone and of the three noncrystalline fractions, as well as with the highest concentration of the two crystalline compounds, as indicated in table 1. Five tests each with approximately 150 flies were made with all but the crystalline materials where three tests each were made. The slides above the compartment containing the flies were removed immediately after spraying of the acetone solutions, but when the kerosene solutions were sprayed a delay of 5 seconds was allowed. Counts were made in the usual manner after 72 hours. Only vigorous flies, showing mortality in the check of less than 10 per cent, were used.

The results are presented in table 1. It is evident that the neutral resin contains

[1] Often called Devil's Shoestring.

[2] The material used in these studies was furnished by G. A. Russell, of the Bureau of Plant Industry, U. S. Department of Agriculture, and V. A. Little, of the Texas Agricultural Experiment Station, for whose cooperation we wish to express our appreciation.

nearly all the toxic material, the alkali-soluble portion and the oil being practically nontoxic. The two crystalline compounds, although isolated from the most toxic fraction, are nontoxic. The neutral resin was slightly less toxic in refined kerosene than in acetone, probably because some of the material was not in solution, and the alkali-soluble portion was slightly more toxic in refined kerosene. In both cases, however, the difference is so small that it is not possible to draw any conclusions about the effect of these turbid solutions in kerosene.

Table 1.—Toxicity to the housefly of fractions of *Tephrosia virginiana*

Material and Concentration	Mortality After 72 Hours When Applied in—	
	Kerosene 95% plus Cyclohexanone 5%	Acetone
Mg./cc.		
Rotenone		
0.125	38%	27%
0.25	65	48
0.50	85	72
Neutral resin		
0.5	11%	11%
1.0	26	34
2.0	66	74
Alkali-soluble portion		
0.5	5%	5%
1.0	10	4
2.0	7	8
Oil		
0.5	7%	2%
1.0	7	3
2.0	8	9
Compound $C_{21}H_{22}O_4$		
2.0	—	4%
Compound $C_{22}H_{24}O_4$		
2.0	—	4%
Solvent only	8%	3%

DISCUSSION.—The *Tephrosia virginiana* root used in these tests contained 1.2 per cent of rotenone and 6.7 per cent of total extractives. The total extractives therefore contained 18 per cent of rotenone and the remainder was composed of approximately 9 per cent alkali-soluble material, 50 per cent neutral resin, and 23 per cent oil. Then, according to the toxicity tests, 68 per cent was quite toxic and the rest can be regarded as inert material. The alkali-soluble portion was composed largely of phenolic substances which may have been affected by the alkali during the process of separation, but the amount of this fraction was small and some increase in toxicity would not have much effect on the total. A similar fraction is found in varying amounts in all rotenone-bearing plants.

The oil in *Tephrosia virginiana* is composed of sesquiterpenes, glycerides, and other minor constituents which have not yet been identified. As would be expected, the toxicity of this mixture as compared with rotenone is practically nothing. This oil does not occur in derris or cubé, but it has been found in all samples of *T. virginiana* thus far examined. Since it may comprise about 20 per cent of the total resin, some allowance should be made if the amount of total extractive is used as one measure of the toxic value.

SUMMARY.—Three fractions of the noncrystalline portion of *Tephrosia virginiana* resin have been prepared and the toxicity of each to the housefly has been compared with that of rotenone. The neutral-resin fraction which comprises approximately 50 per cent of the total extractives, has considerable toxicity, but the alkali-soluble portion, 9 per cent, and the oil, 23 per cent, are nontoxic. The nontoxic nature of the oil should be considered when judging the value of the root from total-extractive content. The two crystalline compounds, $C_{21}H_{22}O_4$ and $C_{22}H_{24}O_4$, which were isolated from the neutral resin are nontoxic to the housefly.—10-29-40.

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Fumigating Action of a Mixture of Orthodichlorobenzene and Naphthalene Applied by a New Method

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The insecticidal properties of orthodichlorobenzene and naphthalene are well known, and these materials have been used with success for the control of some insects. However, their low vapor pressure seriously limits their use, because it is difficult to obtain an effective concentration in a short time. In the case of naphthalene, as well as some other insecticides, considerable progress has been made in overcoming this difficulty, and various devices for increasing the volatilization of naphthalene have been described (Parker, 1928, Hartzell & Wilcoxon 1930, Wilcoxon *et al.* 1933, and Whitcomb 1935). A device for similar treatment of nicotine has been patented by Savage (1932). Recently Sullivan *et al.* (1940) have shown that rotenone and pyrethrum can be dispersed in air by spraying them in solution onto a hot surface. A solution of naphthalene in orthodichlorobenzene has been successfully applied in the same way, and the results of some toxicity tests with this material are reported in this paper.

Materials and Methods.—A solution was prepared by placing 30 grams of naphthalene in a 100-cc. volumetric flask and making up to volume with orthodichlorobenzene at room temperature after most of the naphthalene had dissolved. This amount is near the saturation point and if large crystals are used warming is advisable to speed up the solution.

The dispersion apparatus (Sullivan *et al.* 1940) consisted of a nazal atomizer placed so that the nozzle was 4 inches above an electric hot plate and was operated by a small electric pump to spray the solution onto the heated surface.

The test insects were the American cockroach *Periplaneta americana* L. and the housefly, *Musca domestica* L.

The toxicity tests were made in a 216-cu. ft. Peet-Grady chamber held at 25–28 degrees C. After cages containing the insects had been placed in the chamber (Goodhue & Sullivan 1940), 80 cc. of the solution was sprayed on to the hot plate, which was held at about 375 degrees C., an operation requiring about 8 minutes. Twenty-four hours later the insects were removed to a constant-temperature room, where they were supplied with food and water. Mortality counts were made in the usual manner after 1, 3, and 10 days.

Results.—The results of these experiments are shown in table 1. Complete mortality of the flies was obtained in 24 hours. The roach nymphs showed considerable survival after 24 hours, but after 10 days the mortality of both nymphs and adults approached 100 per cent. The untreated checks showed mortality of not more than 2 per cent during corresponding periods of time.

Table 1.—Fumigating action of an orthodichlorobenzene-naphthalene mixture against the American cockroach and the housefly.

Insect	Number of Tests	Number of Insects	Per Cent Mortality After— 1 day	3 days	10 days
American cockroach:					
Nymphs	—	309	53.6	92.3	98.1
Adults	—	326	94.4	99.4	99.8
Total	9	635	74.0	95.9	99.0
Housefly	4	1200	100.0	—	—

The treatment markedly activated the flies within 30 seconds, and produced a knockdown in 5 minutes and complete immobility 15 minutes after the tests were started. The roaches were affected in 1 to 3 minutes, were violently agitated for the next 10 minutes, and were all on their backs unable to crawl within 30 to 60 minutes.

Discussion.—The results of these tests indicate that the application of orthodichlorobenzene and naphthelene in this manner offers some promise as a method for the control of insects. A much higher concentration can be obtained than by ordinary volatilization, and very little crystallization occurs. During this volatilization process there is some decomposition of the materials and a small amount of smoke is formed. Whether the materials are deposited on the surface as microscopic particles, are absorbed and carried in suspension by the smoke particles, or are electrically attracted to the smoke or fog particles is not known at this time.

In addition to the superior effect due to

the high degree of dispersion, the method has other advantages. The material is relatively nonpoisonous to man, is relatively noninflammable, has considerable penetrating power, and has the property of activating insects; moreover, the cost of treatment is low. Under natural conditions the insects would probably be driven from protecting cracks and cervices, and thus the effectiveness of the toxic agent would be increased. The chief disadvantages seem to be an unpleasant odor, the probable injury to plants, and the limitation of its use to fairly tightly enclosed spaces. As yet no tests have been run under household conditions, and possible damage to goods and food has not been investigated.

SUMMARY.—A new method of applying a mixture of naphthalene and orthodichlorobenzene consists in rapidly volatilizing a solution of naphthalene in orthodichlorobenzene by spraying it onto a surface heated to 375 degrees C. An effective dosage was obtained in about 8 minutes and very little crystallization of the naphthalene followed. Eighty cc. of this solution was used in a 216-cubic foot chamber in which flies and cockroaches were exposed for 24 hours. The mortality of the flies was 100 per cent after 1 day, but more time was required for the cockroaches to die, the nymphs being more resistant than the adults. More than 95 per cent were dead after 3 days and more than 99 per cent after 10 days. The use of these materials applied by this method offers promise for the control of certain household and other insects.—8-18-40.

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Toxicity of Several Nicotine Compounds to *Aphis rumicis* L.

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In a recent paper, the writers (Hansberry & Norton 1940) reported on the toxicity of certain nicotine compounds administered internally to several species of insects. In the present study a larger group of such compounds has been tested as contact insecticides against *Aphis rumicis* L. under laboratory conditions. A future paper will deal with the toxicities of these compounds to newly hatched codling moth larvae. The determination of the relation of chemical and physical properties of nicotine compounds to their toxicity as stomach poisons and as contact poisons has been the major interest in this investigation.

MATERIALS.—Nicotine alginate, 7.90 per cent nicotine. Furnished by the Colloidal Products Corporation of San Francisco. This is gelatinous liquid which forms what is apparently a colloidal solution in water. It has some wetting and spreading properties in the higher concentrations.

Nicotine *Aresket*, 21.48 per cent nicotine. Furnished by the Monsanto Chemical Company of Saint Louis. Apparently a compound of nicotine with an alkyl phenyl benzene sulphonic acid. It has good wetting and spreading properties at concentrations toxic to aphids, and is easily dissolved or dispersed in water.

Nicotine caseinate, 20.64 per cent nicotine. Furnished by the Colloidal Products Corporation. Similar in physical properties to the alginate. Although it is a better wetting agent than the alginate, insects are not entirely wet by the less toxic concentrations since its higher content of nicotine makes it usable in lower concentrations as a spray.

Nicotine humate, 32.7 per cent nicotine. Dr. L. N. Markwood (1936b) of the Division of Insecticide Investigations of the United States Bureau of Entomology and Plant Quarantine kindly furnished this sample. It is a black crystalline solid, soluble in water with difficulty and forming a dense black solution with little wetting and spreading ability.

Double salts of nicotine with cupric chloride (41.86 per cent nicotine), zinc chloride (42.00 per cent nicotine) and stannous chloride (25.13 per cent nicotine) were prepared. These crystalline double salts probably exist only in their solid forms, splitting to form nicotine and the salt in solution. Although the stannous chloride salt is the least soluble it goes into solution completely at the concentrations used in the test.

Nictoine laurate (44.7 per cent nicotine), nicotine oleate (36.5 per cent nicotine) nicotine linoleate (36.6 per cent nicotine) and nicotine stearate (36.3 per cent nicotine) were also prepared. The first three are liquids, the stearate a waxy solid. The stearate does not dissolve completely, but disperses fairly well in warm water. The laurate, oleate and linoleate form either a true solution or a clear colloidal solution in the concentrations used.

Nicotine naphthenate, 36.1 per cent nicotine. This was prepared from naphthenic acid purified by distillation from a sample of crude naphthenic acids with neutralization number of 188 mg. potassium hydroxide per gram and specific gravity of 0.969 furnished by the Shell Oil Company of St. Louis.

Nicotine peat, 10.05 per cent nicotine. Dr. L. N. Markwood (1936a) also furnished this sample compounded with New Jersey peat. Dr. Markwood's analysis of the material showed 88 per cent of the nicotine to be insoluble, approximately 90 per cent of the material to be finer than 150 mesh and 25 per cent finer than 200 mesh.

Nicotine bentonite, 5.4 per cent nicotine. *Black Leaf 155* of the Tobacco By-Products and Chemical Corporation.

Nicotine silicotungstate, 10.12 per cent nicotine. Prepared in the laboratory and probably the least soluble of the compounds tested.

Nicotine Reineckate, 31.76 per cent nicotine. Reinecke salt was prepared by the method of Dakin (1935) from ammonium thiocyanate and ammonium dichromate. The salt is precipitated directly upon the addition of a soluble form of nicotine to a solution of Reinecke salt. A fine powdered precipitate was obtained.

Nicotine resorcinol-formaldehyde, 21.5 per cent nicotine. This was prepared according to the method described by Moore (1933).

Nicotine cuprocyanide, 60.0 per cent nicotine. Furnished by the Niagara Sprayer and Chemical Company. Although not easily wet by water, this earth-like insoluble salt formed a fair suspension in water with good agitation.

Dodecyl nicotinium iodide (36 per cent nicotine), didodecyl nicotinium diiodide (22 per cent nicotine), dodecyl nicotinium bromide (40 per cent nicotine) and didodecyl nicotinium dibromide (25 per cent nicotine) were furnished by the Niagara Sprayer and Chemical Company. All of these were viscous tarry materials, especially the dihalides. When dissolved or suspended in water with the aid of ethyl alcohol as an intermediate solvent, they had excellent wetting and spreading properties, completely wetting the insects at all concentrations used.

Sodium oleate used as a spreader in check experiments was the U.S.P. Neutral Powder. Saponin, purified (Eimer and Amend) was used as a wetting agent with the metal salt combinations and as a check spray with the alkaloid. Distilled water was used in making all dilutions.

METHODS.—Lots of ten alate agamic females of *Aphis rumicis* were used in each individual test. These were taken from the host plant, nasturtium, upon which they had been reared, and placed on moist cotton flannel in petri dishes for spraying. Each concentration was tested against at least six lots of insects, so that each figure in the accompanying table is the mean mortality in six or more replicates. Generally one group of two to five insecticides, together with an alkaloid check, was run at one time. On one day one or more concentrations of each test material would be run, and additional concentrations at later times. Every effort was made in experimental design to keep the comparisons between materials on a statistically sound basis. While this procedure does not make for the best dosage-mortality lines for a single insecticide, it gives more accurate comparisons of materials than if a differ-

Table 1.—Toxicity of nicotine compounds to *Aphia rumicis*—per cent gross mortalities.

	Concentrations Used—Per Cent Actual Nicotine													
	.005	.01	.012	.02	.03	.05	.06	.07	.075	.1	.12	.14	.2	.5	.6
Nicotine compounds															
alginate						15			8	78				100	
Aresket			5				17				78				100
caseinate						15			25	86				100	
humate						8			15	78				100	
$CuCl_2$ double salt[1]	2	3		3			12			30					
$ZnCl_2$ double salt[1]	2	3		7			17			30					
$SnCl_2$ double salt[1]	0	5		17			32			52					
laurate		16			50			95		100					
oleate		28			83			100		100					
linoleate		10			45			100		100					
stearate		30			41			60		98					
naphthenate		26			63			97		100					
peat											18				13
bentonite						30								52	
silicotungstate						1								0	
Reineckate						1								1	
resorcinol-formaldehyde														5	
cuprocyanide														11	
alkaloid[1]					11		25					52	83		
alkaloid[3]		26		70			92					98	100	100	
Nicotinium compounds															
Dodecyl nicotinium iodide[2]						7							23	83	
Didodecyl nicotinium di-iodide[2]						8							37	72	
Dodecyl nicotinium bromide[2]						7							32	80	
Didodecyl nicotinium di-bromide[2]						7							63	70	

[1] One per cent saponin used as supplement.
[2] Ten per cent ethyl alcohol used as supplement.
[3] 0.25 sodium oleate used as supplement.

Checks	*Per cent mortality*
One per cent saponin.	1.7
Ten per cent ethyl alcohol	1.7
0.25 per cent sodium oleate	21.7
Water	0.0

ent insecticide was run at all its concentrations on each day of testing.

The spraying was done with a precision sprayer similar to the one designed by Siegler (1933). Petri dishes containing the insects were placed on an endless belt and passed under the spray nozzle so that each dish received a uniform spray deposit in a constant exposure time. The pressure was 20 pounds per square inch, and the nozzle was 16 inches above the insects. Each dish received a deposit of 0.228 gram with standard deviation of .016 gram. The mean deposit corresponded to 3.2 mg. of spray per square centimeter of area sprayed.

The sprayed insects were immediately transferred from the flannel to fresh nasturtium leaves and held for 24 hours before determining mortality.

DISCUSSION OF RESULTS.—It will be noted in table 1 that the materials have been divided into groups. The identities of the groups are based on their chemical relationship or on the similarities of their physical properties in spray mixtures. Thus the first group includes compounds that are similar in having some wetting and spreading power in their diluted form although not necessarily related chemically. In the second group all are double salts, and because they have little surface activity in spray mixtures, were all used with the addition of one per cent saponin as a spreader. The compounds of the third group are all formed with fatty or naphthenic acids and have good wetting and spreading properties. The insoluble or "fixed" nicotines make up the fourth group and in the fifth are included the nicotinium halides because of their chemical similarity as well as their consistently

high surface activity in spray solutions.

The mortality of the aphids sprayed with compounds in these various groups remains fairly consistent within the groups, but there is marked difference in the efficiency of the several groups. The most toxic group of materials is that including the compounds with fatty and naphthenic acids, namely the laurate, oleate, linoleate, stearate, and naphthenate. With this group should be included the nicotine alkaloid-sodium oleate spray. Much less toxic are the groups of nicotinium compounds, double salts with saponin, and miscellaneous compounds with some inherent wetting and spreading ability. The insoluble compounds or "fixed" nicotines have so little toxicity, as contact insecticides against aphids, that they can hardly be compared with these other groups.

Moore (1918) has reported the high toxicity of nicotine oleate to greenhouse insects, and Garman (1937) found the naphthenate to be effective against aphids.

Apparently these fatty and naphthenic acid compounds have a toxicity that is greater than that of the alkaloid alone, plus the advantage of the wetting and spreading action due to their soap-like nature. The fact that the saponin-nicotine combinations were much less toxic, although they wet and spread as well as this group of compounds, indicates an activating action. Their toxicity is probably influenced by, (1) the toxicity of the nicotine itself, (2) the toxicity of the acid part of the compound, (3) the increase in toxicity due to the good wetting properties, and (4), an unknown activating or synergistic action. That this fourth factor is operative is indicated by the fact that their toxicities exceed that of the sum of the nicotine-saponin kills plus the kill from the sodium oleate used alone. The nicotine alkaloid-soap kill, if corrected for the toxicity of sodium oleate, is greater than that of the nicotine-saponin spray. It is difficult so to correct the kills obtained with the nicotine-fatty acid compounds because increasing concentrations of nicotine contain increasing amounts of the acid component.

SUMMARY.—In the most toxic group of nicotine compounds tested against *Aphis rumicis* are included nicotine laurate, nicotine oleate, nicotine linoleate, nicotine stearate and nicotine naphthenate. Nicotine alkaloid with sodium oleate as a spreader is about equal in toxicity to these compounds. A second and less toxic division contains a group of compounds with good to poor wetting properties, namely, nicotine alginate, nicotine *Aresket*, nicotine caseinate, and nicotine humate; a group consisting of dodecyl nicotinium iodide, didodecyl nicotinium diiodide, dodecyl nicotinium bromide and didodecyl nicotinium dibromide, with excellent wetting and spreading properties; and a group of double salts with saponin as a wetting agent. Insoluble nicotine compounds included the silicotungstate, peat, Reineckate, cuprocyanide, bentonite and resorcinol-formaldehyde. These had little or no toxicity to aphids.

It is suggested that the first group of fatty and naphthenic acid combinations is the most efficient because of the combined toxicity of the alkaloid and the acid, the increase in efficiency due to the wetting and spreading power of the compound and an unknown activating or synergistic action.—8-29-40.

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The Influence of Sodium and Calcium Chlorides on Toxicity of Nicotine to Eggs of *Musca domestica* L.[1]

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It has been demonstrated in several fields of investigation that electrolytes may cause a noticeable change in the toxicity of poisons (Levine *et al.* 1928, Lundy 1938, and Salent and Washeim 1925). N. Levine & Richarson (1934) studied the effect of certain inorganic salts on the paralytic action of nicotine injected into the American cockroach, *Periplaneta americana* (L.). Using low concentrations of nicotine in 0.1 M. solutions of potassium chloride, potassium bicarbonate, sodium chloride, and sodium bicarbonate, they found that practically all these combinations enhanced the toxicity of the alkaloid.

McIndoo (1937) states that twenty per cent of nicotine in 0.1 M potassium chloride was ten times as toxic as the same nicotine concentration in water. His results were obtained by injections into female blowflies, *Calliphora erythrocephala* Meig.

MATERIALS AND METHODS.—The present work deals with the effect of two inorganic salts on the toxicity of nicotine to housefly eggs. Nicotine solutions were prepared in distilled water from a 95 per cent solution of the free base, the concentrations ranging from 0.33 per cent to 1.67 per cent. Similar nicotine solutions were made in normal solutions of sodium chloride and calcium chloride. The nicotine preparations were mixed immediately before their use.

Housefly eggs not over three hours old were treated in a manner similar to that described by Breakey & Miller (1935). The eggs were separated by shaking them in a test tube of water and sub-samples were withdrawn by means of a medicine dropper. Each sub-sample contained from 50 to 100 eggs and represented a random selection from several egg masses. After settling into the tip of the dropper, the eggs were discharged into a test or check solution. The solution and eggs were agitated gently for ten seconds and then were poured over a filter paper in a buchner funnel. The excess liquid was drawn off immediately and the wetted paper bearing the eggs was removed to a petri dish. These dishes were held in a humid chamber to minimize the loss of water. Salt and water controls accompanied each experiment. All tests were made at a temperature of 85°F.

Table 1.—Toxicity of nicotine, and nicotine in two normal salt solutions, to the eggs of *Musca domestica* L.

Percentage Concentration of Nicotine	Net Percentage Mortality of Housefly Eggs		
	Treatment		
	Nicotine	Nicotine in normal NaCl solution	Nicotine in normal $CaCl_2$ solution
0.33	12.99		
0.36	10.91	34.07	
0.38	36.05	49.79	7.65
0.40	28.83		
0.42	32.08	55.73	8.85
0.45	40.32	56.54	13.10
0.48	47.35		
0.50	47.13	64.73	8.50
0.53	50.80		
0.56	63.26	71.17	17.88
0.62	68.21	77.99	21.73
0.71	79.90		28.43
0.83	73.41		22.84
1.00	81.25		37.47
1.25	84.86		42.00
1.67	85.31		76.46
Number of eggs used	7,402	2,530	2,767
Number of sub-samples	100	43	35

RESULTS.—The number of hatched and unhatched eggs at the end of twenty-four hours was used as the criterion of effect. An egg was considered hatched only when the larva was capable of crawling completely out of its chorion. Abbott's formula (1925) was used to convert mortality figures into net mortality, or mortality resulting from the action of the ovicide. These figures were weighted in computing the mean net mortalities, since the number of eggs per sub-sample was not constant. The final mortality data are shown in table 1. Following the method of Bliss (1935), these data were used to derive equations which express the straight line relationship between dosage and response. The linear trends are given in figure 1.

The concentration of nicotine which

[1] From a thesis submitted to the Graduate College of Iowa State College, in partial fulfillment of the requirements for the degree, master of science.

[2] The author is grateful to Dr. C. H. Richardson for his helpful suggestions and criticisms. The writer expresses his appreciation to Dr. F. A. Fenton and the Department of Entomology, Oklahoma A. and M. College, for providing the necessary facilities to perform these experiments.

killed fifty per cent of the population (LD50) was used in making treatment comparisons. Nicotine in water gave a median lethal concentration of 0.517 per cent with a standard error, Bliss (1938), of ±0.009 per cent for a probability of 0.05. The nicotine-sodium chloride solutions resulted in an LD50 of 0.405 ± .011 per cent of nicotine while the nicotine-calcium chloride solutions gave an LD50 of 1.273 ± .55 per cent of nicotine A comparison of these values with their respective standard errors indicates that the LD50 for these treatments differs significantly.

The meaning of these results is not understood at the present time. The most likely explanation might be found in a changed rate of alkaloid permeability resulting from the presence of these salt ions.

SUMMARY.—The toxicity of nicotine to housefly eggs is noticeably altered when the alkaloid is in normal sodium chloride solution or normal calcium chloride solution. The median lethal dose of nicotine in distilled water was 0.517 ± .009 per cent as compared with 0.405 ± .011 per cent in normal sodium chloride solution and 1.273 ± .055 per cent in normal calcium chloride solution.—12-9-40.

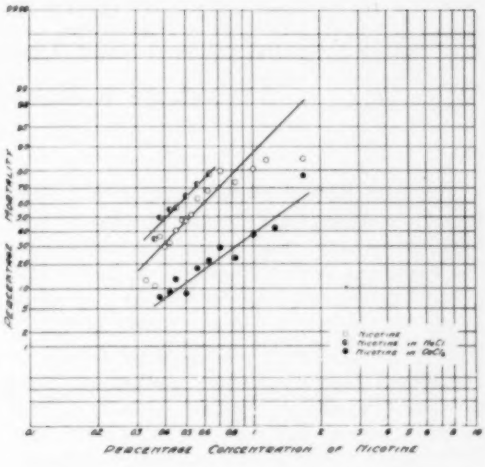

FIG. 1.—Toxicity of nicotine and nicotine in two normal salt solutions to the eggs of the housefly.

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The potato tuber moth and the oriental fruit moth are the subject of new quarantines established by the State of Colorado in December 1940. The areas designated as infested by the potato pest include California, Florida, Texas, Utah, Virginia, and the Territory of Hawaii. Provision is made for the entry of potatoes from moth-free districts of the infested states as determined by light-checking or by inspection, or potatoes may be fumigated under one of three specified schedules. The oriental fruit moth quarantine designates 28 states and the District of Columbia as infested, and prohibits the entry of host materials except dormant, bare-rooted nursery stock when fumigated.

A revision of California's sweetpotato weevil proclamation (No. 9), effective December 3, 1940, changes the infested area in Texas to include the Counties of Hill, McLennan, Falls, Robertson, and Madison, and to eliminate the Counties of Camp, Upshur, and Hopkins, now considered weevil-free.

Bare-rooted willow or poplar trees, cuttings or scions which have been treated at the point of origin may now be permitted entry into California from satin moth-infested areas, under a provision of quarantine proclamation No. 18 of that State, as revised effective December 3, 1940.

Lethal Concentration and Mode of Action of Copper Sulphate Used as a Mosquito Larvicide[1] [2]

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The addition of copper sulphate to the water of mosquito breeding places has sometimes been used as an auxiliary control measure, but little seems to be known about the mode of action of the chemical or the concentration that should be used. Covell (1931), for instance, gives 1 part in 500,000 as adequate for control by alga destruction, and strengths from 1 in 200 to 1 in 5,000 as having been used for direct action on the larvae. The experiments described in the present paper were undertaken with the object of obtaining more precise data on these points.

METHODS.—Experiments were conducted parallel with both the North German and the Portuguese strains of *Anopheles maculipennis* Meig. (var. *atroparvus*) maintained in the Tirana laboratory. The technique was essentially the same as that described by Bates (1939). Eggs were taken from the cages the morning after being laid and placed in an incubator at 27 degrees C. On the morning of the second day they had hatched, and were counted out, 50 at a time, into the experimental dishes containing 100 cc. of solution. A small quantity of ground bread crumbs (about 75 mg.) was sprinkled on the surface and the dish then kept floating in a 27 degree C. waterbath for 72 hours (±2), after which the number of larvae surviving as first and second stage was counted.

Two stock solutions of copper sulphate were made up and used throughout the experiments. One contained 0.01 gm. per cc. of the chemically pure anhydrous salt and the other 0.0001 gm. With these it was possible to make up solutions ranging from 10,000 to 10,000,000 parts of diluent to one part copper sulphate, without adding more than 2 cc. of the stock solution in any case. As media, both distilled water and "Medium S" were used. The latter is an artificial medium, which Bates (1939) found to be favorable for the laboratory culture of larvae of *Anopheles atroparvus;* it contains 0.5 parts $CaSO_4 \cdot 2H_2O$, 0.5 part NaCl and 1.0 part $MgSO_4 \cdot 7H_2O$ in 1,000 parts (by weight) of distilled water. For every batch of larvae used for experiments with copper sulphate in Medium S, control dishes with Medium S alone and with distilled water alone were also carried through.

RESULTS.—The results are given in tables 1 and 2. Each value given for survival percentage is the average value per dish for ten dishes of 50 larvae each. Clearly, a majority of the larvae can survive for three days in the presence of one part $CuSO_4$ in 50,000, but a majority cannot reach second stage, as they always do in the controls, unless the dilution is as much as 500,000 parts to one. There is a large difference between survival percentages in Medium S and distilled water; the larvae do much better, on the average, in Medium S, giving very erratic results in distilled water, but this was to be expected from the known results of rearing larvae in the two media without $CuSO_4$ (Bates 1939).

MODE OF ACTION OF COPPER SULPHATE.—The question is raised whether the $CuSO_4$ harms the larvae directly: as it prevents the appearance of a flourishing micro-fauna which the larvae are presumed to need for food, what do the larvae actually live on in these experiments and how much nourishment do they need?

To determine whether micro-fauna is really necessary, larvae were kept in Medium S in the 27° bath and given extra finely ground bread crumbs sieved through cheesecloth. About every 12 hours the larvae were transferred through two changes of water into another dish of Medium S and given fresh bread crumbs. Another set of larvae was treated in the same way, except that ordinary coarser bread crumbs were furnished instead. A sample of bread crumbs which had been in each dish for 12 hours was examined at every alternate transfer of larvae. At the end of the first 24 hours there was a very moderate number of bacteria in the two "changed" dishes, and no protozoa. A

[1] The studies and observations on which this paper is based were conducted with the support and under the auspices of the International Health Division of The Rockefeller Foundation.
[2] Publication of this paper has been secured by the payment of the costs of printing.

Table 1.—Total survival of larvae of mosquitoes in media containing copper.

PARTS OF MEDIUM S OR OF DISTILLED WATER TO 1 PART $CuSO_4$	NORTH GERMAN *A. atroparvus*				PORTUGUESE *A. atroparvus*			
	Medium S		Distilled water		Medium S		Distilled water	
	Mean per cent	S.D.	Mean per cent	S.D.	Mean per cent	S.D.	Mean per cent	S.D.
Controls	93	6.8	72	43.2	96	5.2	76	18.9
10,000,000	95	3.8	52	46.4	96	4.9	73	30.5
1,000,000	89	13.2	63	36.4	96	5.0	77	19.5
500,000	90	3.9	65	20.8	96	3.9	86	6.9
100,000	78	19.5	11	20.0	90	15.1	8	34.3
50,000	59	32.2	11	35.5	58	10.1	1	2.9
10,000	1	3.0	0	0.0	2	4.8	0	0.0

Average percentages and standard deviations of larvae of North German *A. atroparvus* and Portuguese *A. atroparvus* surviving as first and second stage after 72 hours in various dilutions of $CuSO_4$ in "Medium S" and distilled water. Each figure is based on ten trials, each with fifty larvae.

control dish in which the bread crumbs had not been changed since the beginning contained a few more bacteria, but also no protozoa. After 48 hours, the control dish contained very numerous bacteria and also many flagellates: after 72 hours there were dense masses of bacteria over the whole surface, and, in proportion to their size, an almost equally dense flagellate population. There continued to be no protozoa in the "changed" dishes and few bacteria. The results show that 86 per cent of the larvae fed with fine bread crumbs (34 per cent as second stage) and 66 per cent of those fed with the ordinary coarser bread crumbs (12 per cent as second stage) survived. The larvae must have lived almost entirely on the bread crumbs alone, as the number of bacteria seemed far too small to support them.

Observation of the young larvae under the binocular microscope proved that they did ingest numerous although very small particles of bread. The number of such tiny particles available from coarse bread crumbs is, of course, small; larger larvae could have ingested larger particles. But the larvae were obviously able to get a great deal even from particles too big to be ingested (Puri 1931), but small enough to allow a corner to be introduced between the mandibles. The larvae often "chewed over" such pieces, appreciably reducing the size and undoubtedly removing all loose matter from the surface. The larva would then rotate its head, partly or all the way round, to normal position with the mouth directed downwards and release the unmanageable piece. The particles thus torn from the surface film, sank to the bottom. By this means, the larvae prevent, in a very large measure, the return of the same particles again and again to the mouth on the feeding current where they might interfere with the smaller, readily ingested pieces available in the vicinity.

Thus under these conditions larvae

Table 2.—Survival of second stage mosquito larvae in media containing copper.

PARTS OF MEDIUM S OR OF DISTILLED WATER TO 1 PART $CuSO_4$	NORTH GERMAN *A. atroparvus*				PORTUGUESE *A. atroparvus*			
	Medium S		Distilled water		Medium S		Distilled water	
	Mean per cent	S.D.	Mean per cent	S.D.	Mean per cent	S.D.	Mean per cent	S.D.
Controls	92	7.2	48	34.0	92	11.4	58	10.3
10,000,000	90	8.0	28	33.0	84	16.5	48	10.7
1,000,000	78	13.4	24	16.7	87	16.2	37	7.6
500,000	90	13.2	15	25.4	82	9.7	5	12.3
100,000	12	16.6	0	0.0	30	24.2	0	0.0
50,000	2	3.2	0	0.0	5	6.3	0	1.3
10,000	0	0.0	0	0.0	0	0.0	0	0.0

Average percentages and standard deviations of larvae of North German *A. atroparvus* and Portuguese *A. atroparvus* surviving as second stage after 72 hours in various dilutions of $CuSO_4$ in "Medium S" and distilled water. Each figure is based on ten trails each with fifty larvae.

could survive well the effect of copper sulphate. This is confined to the destruction of the micro-fauna. Nevertheless, the survival of only 66 per cent on the coarse bread crumbs is easily understood, and it must be emphasized that about twice the normal quantity of bread crumbs was supplied in these dishes. Although the micro-organisms are first concentrated near the bread crumbs, they soon scatter throughout the medium, and in decomposing, the crumbs also scatter. Thus, after bread crumbs have been in a dish for three or four days, the larvae always obtain something when they work their mouth brushes. With fresh coarse bread crumbs in the normal amount, the larvae usually get nothing. In the field, where nothing to take the place of the bread crumbs is available, the destruction of the micro-fauna and flora would be decisive.

To determine the direct effects of copper sulphate on the larvae, a set of six dishes was kept in the 27 degrees C. bath, each with 50 Portuguese larvae, as usual, but without any bread crumbs. Two of them contained Medium S, two contained one part $CuSO_4$ to 10,000 parts Medium S, and the other two one part $CuSO_4$ to 50,000 parts Medium S. The larvae were at least 8 hours old when they were put in the dishes. Twenty-four hours later 2 per cent of the larvae in 1:10,000 $CuSO_4$, 1 per cent in 1:50,000, and 88 per cent in Medium S without $CuSO_4$ remained alive. At 42 hours no larvae remained alive in either concentration of $CuSO_4$ and 42 per cent in Medium S alone. The counts of protozoa and visible bacteria in all dishes were virtually nil, for the media had been changed frequently. This shows without any doubt that copper sulphate at the strength of one part in 50,000 can poison the larvae directly, independent of its effect on the micro-fauna. It also shows that young larvae can live almost 30 hours without food.

A set of blank dishes without larvae, but otherwise as in the original experiments, was carried through for three days and the micro-fauna in surface bread crumb samples examined daily. The population density of bacteria and protozoa was graded on an arbitrary scale from zero to 10, although 10, in this case, is less dense than some populations to be seen in long-standing dishes. Table 3 summarizes the results. Tables 1, 2, and 3, taken together, show a clear correlation between micro-faunal density and survival of larvae and it might be assumed this was a directly causal and not a partly coincidental relation, if it were not known that larvae could live through on bread crumbs alone to some extent.

Table 3.—Growth of visible bacteria and protozoa in dishes used in copper sulphate experiments. Population density graded on an arbitrary scale 0 to 10.

		4½ hours		15 hours		37 hours		65 hours	
		Bact.	Prot.	Bact.	Prot.	Bact.	Prot.	Bact.	Prot.
Medium S	Controls	0	0	1	0	7	6	10	10
	$CuSO_4$ 1:10,000	0	0	0	0	0	0	1	0
	$CuSO_4$ 1:500,000	0	0	0.5	0	6	2	8	8
	$CuSO_4$ 1:10,000,000	—	—	—	—	—	—	9.5	9.5
Distilled water	Controls	0	0	0.5	0	3	0	9	2
	$CuSO_4$ 1:10,000	0	0	0	0	0	0	0	0
	$CuSO_4$ 1:500,000	0	0	1	0	5	0	7	0
	$CuSO_4$ 1:10,000,000	—	—	—	—	—	—	9	0

To sum up, at the point reached it appears that, at the higher concentrations, the larvae are killed directly by $CuSO_4$. At intermediate concentrations reduction of food supply may be an indirectly harmful influence, but it is uncertain whether the direct or the indirect effects are more important.

COPPER SULPHATE IN NATURAL WATER.—Both the media used in the experiments above were artificial. When one

part of $CuSO_4$ was added to 10,000 parts of the hard Tirana tap water, a light blue precipitate of copper carbonate was thrown down, much of which settled to the bottom where the larvae do not feed. No such precipitate was formed in the same dilution of $CuSO_4$ in Medium S, but it was formed in ditch water from Yrshek, near Tirana, where *Anopheles maculipennis typicus* abound in summer. One might expect that the addition of a given amount of $CuSO_4$ to such water would be fatal to a smaller percentage of the larvae than the same amount added to Medium S, as less copper would be in solution. A series of dishes using Yrshek water as a medium for the higher concentrations of $CuSO_4$ was, therefore, made up and kept, with 50 Hamburg *A. atroparvus* larvae and bread crumbs, in the 27 degrees C. bath for three days. At the end of that time, in Yrshek water alone, 82 per cent of the larvae were alive (61 per cent second stage). Five such experiments by Bates gave an average survival of 89 per cent with a maximum of 100 and a minimum of 82 per cent. In the six dishes with $CuSO_4$ added, two at 1:10,000, two at 1:50,000, and two at 1:100,000, all the larvae were dead; Table 1 shows that an average of about 80 per cent survived in Medium S with $CuSO_4$, 1:100,000. This large difference may probably be accounted for by the assumption that more copper is actually taken in by the larvae, in the form of solid carbonate, along with other solid food particles filtered out from suspension in the water, than is swallowed or absorbed when the copper is in the form of the sulphate in solution.

The results confirm those of Doty (1905) who found that copper sulphate and lime together produced better results than either substance used alone. Thus the statement of Buxton (1927) that "Unfortuntaely it ($CuSO_4$) is precipitated as carbonate in hard waters, so that it may be much less effective in some countries than others" remains true, except that it may be fortunately rather than unfortunately.

SUMMARY.—Experiments with young larvae of North German and Portuguese ("*cambournaci*," Roubaud & Treillard 1936) strains of *Anopheles maculipennis* var. *atroparvus* showed that fatal concentrations of anhydrous copper sulphate are one part in 50,000 to 100,000 of an otherwise favorable artificial medium at 27° C.

At such concentrations the main effect is a direct poisoning of the larvae, but in greater dilutions the destruction of the food may play a greater part.

The addition of much less $CuSO_4$ is required to kill larvae in natural waters in which copper carbonate is precipitated, probably because the larvae take in more copper when it is present in this solid form.—10-5-40.

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Prohibitive quarantines on the peach mosaic disease were recently established by the States of Georgia and Rhode Island, embargoing the entry of all peach, nectarine, and plum stock from designated areas, including the entire States of Texas and Arizona, as well as infected counties in California, Colorado, New Mexico, Oklahoma, and Utah.

The State Plant Board of Mississippi, on December 12, 1940, amended its sweetpotato weevil quarantine to apply to the entire State of Louisiana. Present regulations of the board also prohibit the movement of sweetpotatoes and the plants from the entire State of Florida, and certain counties in Georgia, Alabama, and Texas.

Laboratory Rearing of Certain Leaf-Eating Insects

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For many years the Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture has undertaken laboratory investigations for the purpose of discovering new materials that might be used for the control of insect pests. This work has been carried on at different times and places in conjunction with projects on the life history and control of various pests. To give greater continuity of purpose and effort to this work, the Division of Control Investigations of this Bureau established a laboratory in Florida in 1936* for the purpose of studying the insecticidal possibilities of new materials.

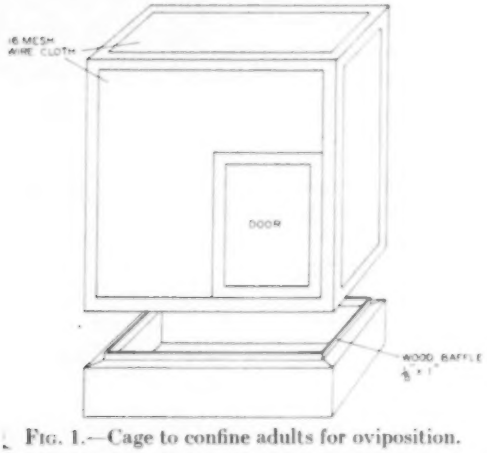

Fig. 1.—Cage to confine adults for oviposition.

When the research at this laboratory was initiated, it was decided to confine the work almost entirely to tests of substances that might be used for the protection of plants against leaf-feeding insects. With this limited field it was possible to work out uniform methods of rearing and testing and therefore save considerable time and labor. This paper describes the equipment and methods of rearing employed in building up a suitable stock of insects on which the insecticide tests could be made.

Production of Food Plants.—In the northern states it has been found difficult or expensive to provide suitable food for the rearing of leaf-feeding test insects during the winter. Although plants may be grown in a greenhouse in the winter or indoors with artificial light (Waters 1937), the space available often limits the work. In Florida it is possible to grow all the foliage necessary in an outdoor garden with little trouble and expense, but in the summer the production of plants is more difficult than in the northern states. The plants that were usually grown for this work were bean, collard, beet, Swiss chard, squash pumpkin, tomato, and potato.

Rearing of Test Insects.—Insects were often used in the testing work at the rate of 5,000 to 10,000 a month. Several times this number were reared in order that a strong rearing stock could be maintained. To supply insects in such numbers it was necessary to simplify the rearing technique so that the cost of the apparatus and labor could be held to a reasonable figure. The equipment and procedure have been modified repeatedly as experience suggested desirable changes. Although a score of different insects have been reared in the laboratory, only a half dozen different pieces of equipment were used. A brief description of these is given below.

Oviposition Cage.—The type of cage used for this purpose is shown in figure 1. This unit was composed of two parts, namely, a screened cage and a shallow-box bottom. The cage itself was a cube, 15 inches on a side, and was made of 16-mesh wire screen tacked over a framework of three quarter by three quarter inch strips of wood. A door measuring approximately 7½ by 10 inches was placed as shown in figure 1. This cage was left unscreened on the bottom side, where it fitted snugly over the top of a box. These box bottoms were constructed of three quarter inch lumber and were 15 inches square and 3 inches deep. The bottom side was covered with a piece of 28-gauge galvanized sheet iron nailed to the bottom edge of the side strips. A thin wooden baffle about the upper inside edge of the box prevented the cage from slipping off the box and also sealed the joint against the passage of insects. When in use the bottom box was filled with moist sand to a depth of 2 inches and a small flask of water was placed on the sand in the center of the box

* The laboratory was established at Orlando but was moved to Sanford in 1937.

to hold leaves of the host plant. Often a shallow dish containing moist cotton and a little honey solution was placed on the sand for adults that fed on nectar. Such a cage accommodated sufficient adults of most species to supply all the eggs needed.

LARVAL REARING CAGE.—Two types of larval rearing cages were employed because of the difference in requirements and behavior of the various species of insects. For larvae that crawl about the cage a great deal a unit such as is shown in figure 2 was used. This type also was used for larvae requiring as much light and air as possible. The bottom, or flat, of this unit was identical with that of the oviposition cage and the two were therefore interchangeable. The top was a cubical cage,

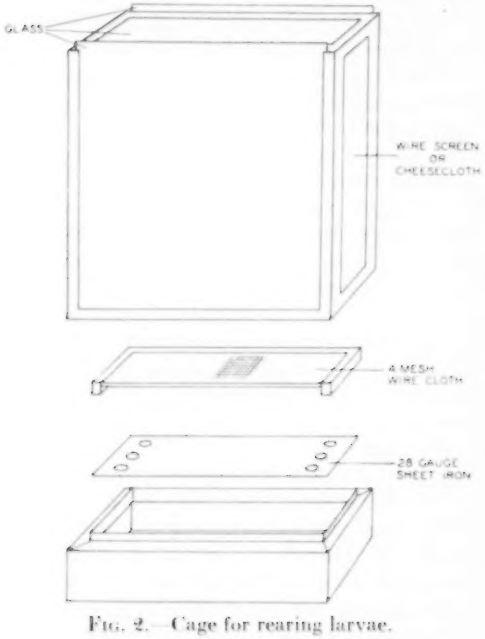

FIG. 2.—Cage for rearing larvae.

15 inches on a side, with 16-mesh wire screen, cheesecloth, or muslin, tacked on two opposite sides. The top and two remaining sides were of glass. These glass sides were inserted in small grooves in the uprights so that they could be removed by grasping the extending upper edge and withdrawing upward. These sliding glass panels therefore served as a means of access to the interior of the cage for feeding purposes and other care. They could be opened only slightly or completely withdrawn.

A sheet of 28-gauge galvanized iron generally was placed on the narrow baffle strip between the cage and its bottom. This sheet, which was 13½ inches square and had 6 holes, 1 inch in diameter, punched through it, caught all the refuse and could be removed and cleaned period-

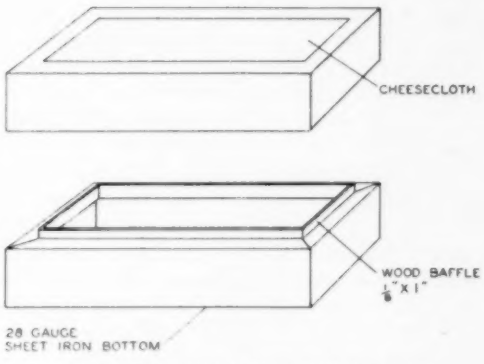

FIG. 3.—Standard bottom with box top for rearing larvae.

ically. On top of this metal sheet rested a wooden frame, 1-inch thick, which was covered across the top with ¼-inch-mesh hardware cloth. On this screen were placed the leaves on which the larvae were to feed. The holes in the metal sheet permitted the full-grown larvae to enter the box where they could pupate in the soil or rough toweling paper previously placed in the box. Species pupating in soil were allowed to remain there until emergence, at which time the larval cage was removed and an oviposition cage substituted for it. Thus the pupae were not disturbed and the adults emerged directly into the oviposition cage. With species that do not pupate in soil, it was generally more convenient to transfer the emerging adults to the oviposition cage by hand.

Larvae that tend to remain on the foliage rather than crawl about over the cage were more conveniently kept in a box such as shown in figure 3. This box was a compact unit composed of the regular bottom shown in figures 1 and 2 and a top 15 inches square and 3 inches deep. The upper side of this top section was covered with cheesecloth, which permitted the circulation of air but prevented the escape of the smaller larvae. Sandy soil was placed in the bottom for pupation when necessary; otherwise, only sheets of toweling paper were used. Advantages in this type

of insect box were the convenient size and the ease with which the top could be removed.

Seven-inch glass battery jars were used for certain phases of the rearing work. Usually these were replaced by the boxes just described, but for some purposes they were still unsurpassed. For some insects they could be used for all phases of rearing, but for others they were unsatisfactory because they lacked the necessary circulation of air.

In certain cases it was essential to maintain the foliage in a fresh, unwilted condition in the rearing cages. This was especially true if the larvae were small and did not consume all the foliage within 24 hours. Flasks and beakers of water were unsatisfactory, since they tended to bunch the leaves and support them so high that they were not readily accessible from the floor of the cage. To overcome these objections, a water fount, such as is used for watering young chicks, was found serviceable. A pint fruit jar of water screwed into the fount supplied water for the foliage for several days. The fount fitted neatly into the rearing box (Fig. 3) and permitted the leaves to lie flat and touch the bottom.

CONDITIONS FOR REARING.—No effort was made to control the temperature, humidity, or light in which the rearing work was conducted. Controlled conditions are perhaps desirable but not absolutely essential, for suitable insects could be reared under ordinary laboratory conditions. Extremes in temperature caused the most trouble and were guarded against by heating and ventilating the laboratory.

METHODS OF REARING.—Twenty species of insects have been reared from time to time since the work began. Not all these proved to be satisfactory laboratory insects, and as this fact became apparent the less promising species were dropped. The rearing of each of 12 satisfactory species is described in the remainder of this paper. Previous observations on the rearing of some of these species can be found in the manual by Peterson (1937).

The technique used for each species is based on experience covering a comparatively short period and in some cases might require revision to facilitate continuous rearing over a period of several years. The time required for a complete life cycle of the species described ranges from approximately 28 to 38 days under favorable conditions, and all but the Colorado potato beetle can be reared at this rate without regard to seasons. Attempts to rear the potato beetle at this rate through the year were unsuccessful because the late-summer individuals hibernated despite efforts to control environmental conditions that were thought to influence this phenomenon.

No study was made to determine the number of successive generations that might be reared without the addition of fresh stock from the field. The southern armyworm, however, was reared for as many as 20 generations without subsequent collections being necessary. The cross-striped cabbage worm, imported cabbage worm, southern beet webworm, Hawaiian beet webworm, and melon worm were all reared for as many as 12 consecutive months without any apparent need for introductions of new stock.

With some species disease often wipes out the stock before many successive generations can be reared, but this condition apparently is not due to a weakness brought on by inbreeding. It has not been the practice in these studies to introduce fresh stock in an attempt to strengthen the resistance of the population, but rearing conditions that might prove satisfactory have been investigated. Introduction of field-collected individuals appeared likely to complicate attempts to make the laboratory population more uniform, a desirable objective in this type of work.

CABBAGE LOOPER.—The cabbage looper *Autographa brassicae* is very prolific in the laboratory, but the larvae are often difficult to rear because of their susceptibility to disease. Adults were confined for oviposition in battery jars because they were found to lay readily on screen cages or other equipment placed in the cage. Although a collard leaf was generally placed in the jar, the moths readily oviposited on the jar and on the muslin cover. It was therefore necessary to transfer the adults to another jar each day in order to divide the eggs into groups of similar ages. When eggs began to hatch, a flask containing several collard leaves was placed in the jar to supply food for the young larvae. After 2 or 3 days the larvae were transferred to a rearing box containing collard leaves which were kept fresh in the water fount. These leaves were replenished daily until the larvae were fully

grown, when they pupated in cocoons fastened about the inside of the box. After the larvae were half grown, it was found unnecessary to keep the collard leaves in a water fount, for they were usually consumed before serious drying out could occur. The newly emerged adults were transferred to oviposition jars by gently removing the tops of the rearing boxes and collecting the undisturbed moths in a small vial.

CABBAGE WEBWORM.—The cabbage webworm *Hellula undalis* (F.) is smaller than the cabbage looper but more easily reared in the laboratory because of its resistance to disease. As in the case of the looper, the adults were confined in glass battery jars because they readily oviposited on the cage rather than on the host plant. With 25 to 30 adults to a battery jar, it was possible to confine most of the oviposition to collard leaves by placing in the bottom of the jar a leaf which had been crumpled in the hand. When the eggs had hatched, the young larvae were fed on collard leaves placed in a flask of water in the jar. After several days the larvae were transferred to a rearing box, where they were fed on collard leaves until fully grown. Toweling paper was generally placed in the bottom of the box and the larvae pupated under the edges of this, on the collard leaves, and in the corners of the box. By gently removing the top of the box, the emerging adults could be collected in a vial and transferred to an oviposition jar.

COLORADO POTATO BEETLE.—The Colorado potato beetle *Leptinotarsa decemlineata* (Say) is an excellent test insect, but was not found to be adaptable to year-round production. At Sanford, the insect is active from April through June, and laboratory methods have not materially extended this time. Since it is almost impossible to grow host plants in this locality during the summer, efforts to carry the insect through this season probably would be impractical.

Adults were kept in an outdoor cage 12 feet long, 9 feet wide, and 9 feet high, which was covered with 16-mesh wire screen. Potato plants were transplanted into this cage as often as needed from rows in the garden. It was found necessary to maintain a large amount of foliage in the oviposition cage so that the egg clusters would not be eaten by the adults. At least 1,000 adult beetles were needed to maintain an ample supply of larvae for the insecticide tests. Egg clusters were collected each day from this cage, and after the excess leaf was trimmed from around the clusters they were placed in petri dishes. The newly hatched larvae were placed on potato foliage in a rearing box until nearly full grown, when they were transferred to another box containing moist sand, in which they pupated. Emerging adults were collected daily and placed in the large outdoor cage.

CROSS-STRIPED CABBAGE WORM.—Adults of the cross-striped cabbage worm *Evergestis rimosalis* (Guen.) are very prolific and oviposited heavily on collard leaves placed in a small flask in an oviposition cage. This cage was generally kept indoors, for the adults appeared to lay as well under these conditions as they did outdoors. When the cage contained as many as 100 adults, the collard leaves were removed daily and fresh leaves added. These leaves, which generally bore several thousand eggs, were placed in a battery jar with a tight muslin cover. The newly hatched larvae were fed on collard leaves for several days in the jar and were then transferred to a rearing box for increased space and better aeration. Collard leaves were added daily and held in a watering fount in the center of the box. When fully grown, larvae in sufficient numbers to maintain the rearing stock were transferred to battery jars containing sand, in which they pupated. Jars were used for this purpose because the emerging adults could be transferred readily to an oviposition cage by inserting the mouth of the jar through the door of the cage. This procedure permitted the maintenance of a single oviposition cage, in which the desired number of adults were kept by daily addition of those emerging in the jars.

DIAMONDBACK MOTH.—Diamondback moths *Plutella maculipennis* (Curt.) were confined in an oviposition cage containing a potted cabbage or collard plant. Best results were obtained when the cage was kept outdoors, although protection from rain was necessary. Shortly before hatching of the eggs the plant was placed in a battery jar to prevent the escape of the newly hatched larvae, which were found to leave the plant when crowded. After the plant had been consumed, the larvae were

fed collard leaves and shortly removed to a rearing box. The larvae pupated on the foliage in the box, and the pupae were removed daily to petri dishes in order that the old foliage could be discarded. After emerging in the petri dishes, the adults were transferred to an oviposition cage.

GREENHOUSE LEAF TYER.—Adults of the greenhouse leaf tier *Phlyctaenia rubigalis* (Guen.) were placed in an oviposition cage, together with foliage of Spanish-needle, *Bidens leucantha*, which is one of the preferred host plants and is easily obtained. The cage was left indoors. The foliage was removed from the cage daily and placed in a water fount in a rearing box, which kept it fresh until the eggs hatched. The young larvae were fed collards or *Bidens* until fully grown, when they pupated on the foliage in the box. As the old foliage was discarded, these pupae were removed and placed directly into the oviposition cage, where they later emerged.

HAWAIIAN BEET WEBWORM.—Adults of the Hawaiian beet webworm *Hymenia fascialis* (Cram.) were confined in an oviposition cage which was kept indoors. Foliage of pigweed, *Amaranthus* sp., was placed in the cage for oviposition. This is one of the preferred host plants and is very attractive to the female moths. Beet and Swiss chard leaves are also satisfactory, but deteriorate more rapidly before the eggs hatch. Foliage was removed daily from the oviposition cage and kept in a battery jar until the eggs hatched. Larvae of this species were fed beet or Swiss chard leaves in a rearing box. Swiss chard was found better for this purpose, since it did not decompose so rapidly as beet. Shortly before pupation the larvae were transferred to battery jars containing moist sand. In a short time they pupated in the top layer of sand and were held there until emergence, when they were easily transferred to an oviposition cage.

IMPORTED CABBAGE WORM.—Adults of the imported cabbage worm *Pieris rapae* (L.) must have sunlight for maximum oviposition and are completely inactive if kept indoors in the subdued light of the average building. With sunlight they were found to oviposit normally in cages of almost any size. Rectangular cages 30 inches square on an end and 3 feet long were convenient for this purpose, since they were large enough to cover small flowering shrubs on which the adults fed. Lantana was most generally used for this purpose, because it was attractive to the adults and bore many flowers over a long period. The cage was so placed that the flowering lantana occupied one end, and the other end was left free for a potted collard or cabbage plant, which was introduced daily through a small door. Plants bearing eggs were held where natural light would prevent the yellowing and falling of the leaves. After the young larvae had nearly consumed the plants upon which they had hatched, they were transferred to a rearing box and fed collard leaves until fully grown. The mature larvae were transferred to battery jars for pupation, as the adults could then be removed to the oviposition cage easily.

MELONWORM.—The melonworm *Diaphania hyalinata* (L.) thrives and is very prolific under laboratory conditions. Eggs were obtained from adults confined in an oviposition cage indoors. Squash leaves were placed in the cage daily, and those bearing the eggs were put in a battery jar. When the eggs had hatched, fresh squash or pumpkin leaves were placed in the jar daily for several days. The larvae were then transferred to a rearing box, where they were kept until fully grown. They pupated in the corners of the box and under the edges of toweling paper in the bottom of the box. After all the larvae had pupated, they were removed to a shallow dish, which was placed in the oviposition cage for emergence.

SOUTHERN ARMYWORM.—The southern armyworm *Prodenia eridania* (Cram.) is a hardy species and is readily adaptable to laboratory rearing. The adults were confined in an oviposition cage, together with foliage of Spanish-needles. The cage was kept indoors. Egg masses were generally cut out of the leaves with a sharp knife and placed in petri dishes so that newly hatched larvae could be fed on collard leaves from the start. These were transferred to a rearing cage and placed on collard leaves held in a water fount. The box bottom of the rearing cage was partially filled with sand and the metal tray and screen were always used with this species. Fresh foliage was added to the cage daily until the larvae were fully grown, when they entered the bottom of the box and pupated in the sand. When all had pupated, the upper cage was removed and an oviposition cage substituted in its place.

In this way the pupae were not disturbed and the adults emerged directly into the oviposition cage.

SOUTHERN BEET WEBWORM.—The rearing technique for the southern beet webworm *Pachyzancla bipunctalis* (F.) was the same as for the Hawaiian beet webworm except that the larvae pupated in toweling paper instead of sand. This paper was subsequently removed to a battery jar until emergence of the attached pupae.

YELLOW WOOLLY BEAR.—The yellow woolly bear *Diacrisia virginica* (F.) is very hardy and prolific when reared under laboratory conditions. The technique employed was the same as for the southern armyworm except that the larvae did not pupate in sand but in hairy cocoons attached to the collard leaves on which they had been feeding. These were removed as the foliage was discarded and were placed in the oviposition cage for emergence.

SUMMARY.—Laboratory methods of rearing 12 leaf-eating insects for use in toxicological studies are described. Oviposition and rearing cages that were inexpensive and permitted the rearing of the insects in relatively large numbers are illustrated and described. Cages employing units that were interchangeable facilitated the rearing of the stock with a minimum of handling. A water fount, such as is used for watering young chicks, was found useful for maintaining foliage in a fresh condition.—11-24-40.

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Laboratory Testing of Natural and Synthetic Organic Substances as Insecticides

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In the preceding paper the authors have described laboratory methods for rearing 12 species of truck-crop insects. These methods were worked out to supply large numbers of insects for use in testing the toxicity of synthetic organic compounds and plant materials* in the laboratory of the Bureau of Entomology and Plant Quarantine at Sanford, Florida. The purpose of this paper is to describe the method and equipment used in testing these materials on the insects.

The research carried on at this laboratory has been confined largely to studies of the toxicity of various substances to leaf-feeding insects and the effect of these materials on plant foliage. At the same time, substances having contact or fumigating action were not overlooked by the method of testing to be described. The widespread demand for new and improved insecticides has made this type of work of great importance.

* The organic compounds were supplied by the Division of Insecticide Investigations, Bureau of Entomology and Plant Quarantine, and the plant materials by the Division of Drug and Related Plants, Bureau of Plant Industry.

Since a large number of materials were to be studied, it was desirable to work out a preliminary test that would eliminate the nontoxic samples immediately and allow concentration of the work on those that showed some degree of toxicity. In any such attempt certain characteristics of insects have to be considered in order that comparable results may be obtained. For example, in comparative tests of different samples it is essential that the same species and the same instar or stage be used and, in the case of leaf-feeding insects that they be reared consistently on the same foliage. Furthermore, the foliage used in the insecticide tests should be standardized as much as possible, because the toxicity of an insecticide may be influenced by the foliage on which it is applied. In general, the earlier instars are much more easily killed than are the older larvae, and the selection of the instar to be used will control, to a large extent, the number of samples that will appear promising as insecticides.

A procedure for applying dust to foliage

has been described by Campbell & Filmer (1929), in connection with their sandwich method of testing insecticides, and improved by Bulger (1932). The sandwich method was designed to determine the amount of insecticide required to kill individual larvae and appeared too laborious for large-scale testing to eliminate nontoxic materials. A simpler method was devised that would establish the fact of toxicity only as a basis for segregating the samples.

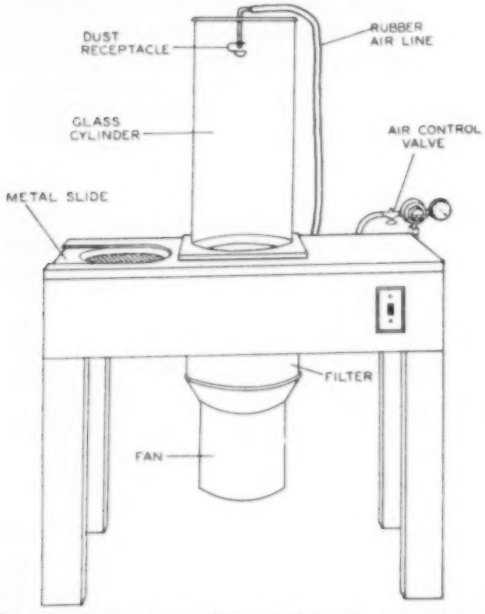

FIG. 1.—Apparatus used for applying dust to foliage in testing insecticidal action of organic compounds.

PRELIMINARY TOXICITY TESTS.—The first tests made on all materials that could be applied as dusts were designed to eliminate the nontoxic samples and to establish the approximate toxicity of the promising samples. The materials were dusted on foliage and the foliage was confined with larvae in closed petri dishes (Swingle & Cooper 1935). These tests made possible stomach-poison action, contact action, and fumigation by vaporization of the material in the closed dish.

The sample was ground in a mortar with a pestle to improve its fineness when this was thought necessary. Leaves from host plants of the insects to be used were cut into three sections approximately $1\frac{1}{2}$ inches square and the sample was dusted over the leaves in the apparatus shown in figure 1. The dusting chamber was a glass cylinder, 11 inches in diameter and 24 inches high. It was mounted on a special table containing a metal drawer-slide (fig. 2), which permitted the introduction and withdrawal of the leaves. On one end of this slide was a circular recess, 1 inch deep, with a solid bottom, which was designed to catch all excess material settling through

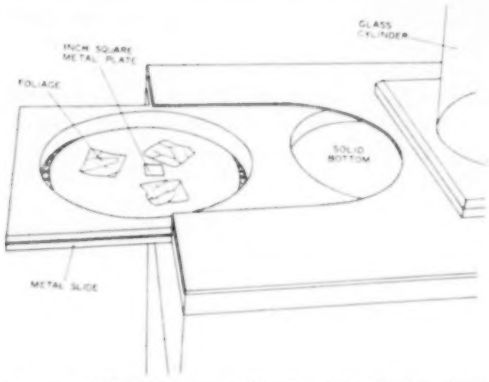

FIG. 2.—Metal drawer-slide for introducing leaf sections under dusting cylinder.

the cylinder during the process of dispersing the dust. On the other end of the slide was a similar recess with a bottom of three-eighths-inch-mesh hardware cloth, which held the leaves and permitted the unused dust in the cylinder to be drawn out through the bottom. Below the cylinder, and attached to the underside of the table, was a cylindrical sheet-metal housing, which contained a filter and a suction fan controlled by a switch on the right front of the table. The filter was a disc of fine steel wool 3 inches thick. The steel wool was impregnated with light machine oil and was easily replaced when saturated with dust. The dust receptacle, which also dispersed the dust, was located just under the cover on the top of the glass cylinder. It consisted of a round, measuring teaspoon the handle of which was bent and attached to the tip of a $\frac{1}{4}$-inch air jet, as shown in figure 1.

Approximately one-fourth teaspoonful of the dust was put into the receptacle, and the slide in the table was so placed that the solid-bottom recess was directly beneath the cylinder. A large disc of coarse filter paper was then placed in the recess with the hardware-cloth bottom, and the leaf sections were placed in the center about a weighed metal plate measuring 10 square centimeters (Fig. 2). Air

was released from a reservoir under approximately 8 pounds pressure by a quick-acting valve and directed through the jet onto the dust, quickly fogging the top portion of the cylinder. Several seconds were allowed for the larger particles to settle out, and the slide was then moved to the right, bringing the recessed portion bearing the leaves and plate under the cylinder. This portion was held under the dust for 1 minute and then withdrawn. The leaves were turned over with forceps, and the dusting was repeated on the other side. The dusted leaves were then transferred to petri dishes. The metal plate was reweighed to ascertain the weight of dust applied per square centimeter.

After the dusted leaves were removed, the filter paper was discarded and the hardware cloth was drawn under the cylinder once more. A suction fan below the filter was then started, and the cover of the cylinder was slightly raised to admit air. The dust-laden air in the cylinder was removed in a few seconds into the filter. The inside of the cylinder and the dust receptacle were then cleaned with a dry cloth. When large numbers of unfamiliar organic compounds are to be tested, such a filter is almost necessary as a precaution against possible eye, nose, and throat irritation.

One dusted leaf was placed in each of three 9-cm. petri dishes, together with 10 nearly full-grown larvae. After 48 hours the larvae were examined for possible mortality, and the amount of feeding on each leaf was estimated. Larvae were considered dead if they showed no movement on being probed, but after some experience their condition could be determined visually. For comparison similar tests were made with a standard insecticide, such as lead arsenate or derris.

The interpretation of the results depends as much on the amount of feeding recorded as on the mortality, because most of the larvae could fast for 48 hours if confronted with an extremely repellent material on the leaf. In other words, high mortality was always significant, but low mortality did not necessarily mean a poor compound, unless it was accompanied by almost normal feeding. The amount of dust on the leaves is, of course, very important and, for preliminary testing, experience has shown that each leaf surface should be covered with a deposit approximating 200 to 250 micrograms per square centimeter. Each sample was tested on three to eight different insects, because organic materials are often specific in their action, some being ineffective against some species but very toxic to others. Samples that were consistently nontoxic were eliminated from further testing, but those that greatly retarded feeding or caused a high mortality were given further tests.

FUMIGATION TESTS.—Samples that gave approximately 100 per cent mortality within 48 hours, when there was little or no feeding, were suspected of causing death by fumigation. This mortality could also have resulted from an extremely toxic contact or stomach poison, but fumigation tests were made to get more information on this point. A leaf section and 10 larvae were placed in each of three petri dishes, and a quantity of the sample was placed between two sheets of filter paper pressed into the top of the dish. This permitted volatilization of the compound within the dish, but prevented contact between the insects and the insecticide. No effort was made to facilitate volatilization of the material, as would be done in regular fumigation studies, for the tests were designed only to interpret results of previous tests made under somewhat similar conditions. Samples causing high mortality were classed as fumigants, or contact poisons by vaporization, and were therefore not tested as stomach poisons.

SCREEN-CAGE TESTS.—Samples which showed considerable toxicity in the preliminary tests and which were found not to be fumigants were considered promising as contact or stomach poisons. To demonstrate in a more practical way the insecticidal possibilities of these samples, a method of cage testing with potted plants was used with good results. Furthermore, it was early recognized that some method must be worked out which would prolong the testing period beyond the 48 hours used in the tests with petri dishes. Many of the samples had shown a strong repellent action, and the only practical method of carrying on such tests seemed to be with potted plants, which could be kept in a normal condition for a long time. Cut leaves of any kind were not suitable for this purpose. The use of potted plants also facilitated a spray application and resulted in tests with characteristics more

similar to those in field work. This method was also used in preliminary tests of samples that were received as liquids or were otherwise not suitable for dusting.

In the cage tests all materials were applied as sprays, prepared in the proportion of 8 pounds to 100 gallons of water. Supplemental tests at lower concentrations were made of the better compounds. The preparation of a good spray was not always a simple matter, because the physical and chemical properties of the samples varied greatly. Various agents were used to disperse and suspend the samples in water. The best results were obtained with saponin, used in the proportion of 1 pound per 100 gallons of water. A measured quantity of a solution of saponin and the chemical sample were ground in a mortar to a thin paste, followed by dilution with water to the required concentration. *Aresket*, bentonite and blood albumin were also used with good results on many samples. When greater spreading power was desired for plants with a waxy surface, a small quantity of *Orvus 20-A* was added to the spray.

Spraying was accomplished by means of a compressed-air gun such as is used in paint spray outfits. A small glass bottle holding 100 cc. of liquid was screwed to the bottom of the gun, making the outfit portable and facilitating coverage of the entire surface of the plant. The plants were grown in an outdoor garden and were transplanted into 6-inch pots a day or two before being used. Those from 5 to 8 inches high were found the most satisfactory. Both sides of the leaves and the stems of two plants were carefully sprayed, and the plants were set aside in the shade until dry. Cylindrical cages made of 16-mesh wire screen, $5\frac{1}{2}$ inches in diameter and 12 inches high, were placed over the sprayed plants and gently forced into the soil about the inside edge of the pot. Fifteen insects were put into each cage through the open top, which was then closed with a piece of cheesecloth held down with a rubber band. The caged pots were placed on shelves out of doors in a location which was sheltered from direct sunlight and rain. After 48 hours the insects were examined and the amount of feeding was estimated. If all the insects were dead or the plant was consumed, or killed by the spray, the test was so recorded and discarded. If mortality was not complete and the plant was intact or only partly eaten, the cage was examined every 2 days thereafter until either the insects were dead or the plant was consumed.

In the cage tests the insects either ate the plants or died. There were no alternatives, since no other food was available and the tests were continued beyond the limit of fasting. Many of the samples found toxic in the preliminary tests caused no mortality in the cage tests because of the comparatively small deposit applicable by the spray method and the possibility of volatilization of this deposit in the open air before the insects began to feed. These are conditions which have to be met by any insecticide used in the field. Furthermore, compounds acting as contact insecticides only may not be toxic in this type of test, in which a relatively small deposit adheres to the leaves. Such samples must be reserved for contact tests in which the insecticides are applied directly to the insects.

PHYTOTOXICITY TESTS.—After the toxicity of a sample had been established by the petri-dish and screen-cage tests, the material was applied to several truck-crop plants to determine whether it could be used with safety on tender foliage. The sample was prepared as a spray at the rate of 8 pounds per 100 gallons and applied with a hand sprayer to truck crops growing in a garden. Plants most generally used for this purpose were bean, collard, beet, squash, tomato, and potato. Young plants about 6 inches high were used, because they were considered more tender and had fewer spotted or yellow leaves than older plants. Small plots of a half dozen varieties were sprayed with each sample, care being taken to cover all portions of the plants. Although it was generally possible to make these foliage tests during periods of mild temperature and no rainfall, records of environmental conditions were kept. The plants were carefully examined after 2, 5, 10, and 14 days for burning or other injury not directly traceable to environmental conditions, comparison being made with unsprayed check plots. Because of changing weather conditions this outdoor method of testing for foliage injury is not so reliable as the indoor, high-humidity method described by McGovran & Farrar (1936) and Waters & Witman (1937). On the other hand,

it is not so severe a test and is more representative of practical conditions. Under high humidity insecticides show less promise than under natural conditions, and the policy in this work has been to encourage the practical testing of all materials toxic to insects. The use of tender truck-crop plants is a rather severe test, and the fact that a compound is toxic to this type of foliage does not necessarily mean that it cannot be used on other plants. Each host plant is a problem in itself and must be studied as such before recommendations can be made.

SUMMARY.—In laboratory tests of the toxicity of synthetic organic compounds and plant materials to truck-crop insects a settling dust chamber was developed to apply the powdered samples to excised foliage. This duster facilitated the application and measurement of the dust deposit and permitted the removal of the unused dust from the cylinder into an oil filter. Sections of dusted foliage were confined in petri dishes with leaf-feeding larvae to determine initial toxicity of the dust.

Compounds giving high mortality with limited feeding were tested as fumigants in petri dishes by isolating the chemical from the larvae. Toxic materials other than fumigants were suspended in water and applied as sprays to potted plants. Larvae were confined on the sprayed plants by cylindrical wire-screen cages. Materials that were toxic in the petri-dish and screen-cage tests were applied as sprays to tender truck-crop plants to check on possible toxicity to foliage.—11-24-40.

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Lygus Injury to Peaches in the Pacific Northwest and Its Prevention

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Several species of *Lygus* have been responsible for severe damage to peaches in the Pacific Northwest. In 1938, 1939 and 1940 some orchards ran as high as 50 per cent cullage, due to "Monkey-facing" or "Cat-facing" caused by *Lygus* bugs. This cullage was on the picked crop and did not include culls removed during thinning.

In 1940, experiments were planned to determine at what stage of fruit development the injury was done and which of the several species of *Lygus* were responsible. The orchard selected was near Wenatchee, Wash.

EXPERIMENTAL.—Small wire sleeve cages were placed over peach buds in the early spring before the bud scales began separating. Pollen was collected, dried, and the blossoms within the cages were hand pollinated to insure fruit set in the absence of pollinating insects. The cover crop in the peach orchard, alfalfa and sweet clover, was swept with a net. The *Lygus* bugs thus collected were then segregated into species and placed in the cages.

Two *Lygus* bugs of the same species were introduced into these cages at a certain stage of the fruit development and removed from the cage at the end of a certain period of fruit growth (Table 1). These cages were then observed for injury until thinning time. At that time all the cages were removed and the final counts were made. There were, in all, sixty cages used. Some were used as checks and had no insects within them.

The bugs, as they were removed from the cages, were chloroformed, mounted, numbered and sent to Dr. H. H. Knight of Iowa State College for final identification.

FIG. 1.—Dusting peaches for prevention of Lygus damage.

Table 1 gives the summary of the species involved and the stage of fruit development during which the injury was done.

It may be seen from table 1 that the injury to the crop of peaches occurs only from the time the pink begins to show until the shucks fall. There are only three species of *Lygus* that are responsible for this injury to peaches. They are *Lygus elisus* Van D. *Lygus hesperus* var. *viridiscutatus* Knight., and *Lygus* sp., *Lygus hesperus* Knight and *Deraeocoris brevis piceatus* Knight have been caught in bait traps but have never been found either in peach trees or cover crops in the peach orchards.

These cage tests probably showed a more severe injury than normal, since the bugs were confined in the cages with nothing else to feed on. Field observations also indicated that injury occurred between the time the pink showed and shuck fall.

Blossoms and peaches in cages without any *Lygus* bugs were not injured at all and developed into first grade fruit.

CONTROL MEASURES.—An eight acre peach orchard was used for a commercial test of Pyrocide Dust. This dust was made by mixing 10 per cent of *Dry Pyrocide* with 90 per cent of talc and contained 0.2 per cent pyrethrins. It was used at the rate of 40 to 50 pounds per acre and the entire acreage received the treatment.

The dust was applied with a power duster, with fishtail fins. The dust was blown out on both sides, penetrating the trees and cover crop. (Fig. 1.) The duster was towed by a tractor at about 4 to 5 miles per hour, going up one row and down the next. The eight acres were dusted in about three quarters of an hour. The best results were obtained when the dust was applied about sunrise.

Table 1.—Stage of development of fruit in relation to injury by various species of *Lygus*.

	Period Bugs Were Confined in the Cages				
Species	No Pink showing to Buds opening	Buds in Pink Stage to Just past full bloom	Just opening to Shuck fall	Full Bloom to Shuck fall	Shuck fall to Thinning
Lygus elisus	All buds blasted	All but a few buds blasted	30 blossoms blasted 2 peaches injured None uninjured	11 blossoms blasted 18 peaches injured 3 uninjured	No injury
Lygus hesperus var. *viridiscutatus*	All buds blasted	All buds blasted	42 blossoms blasted 1 peach injured 2 peaches uninjured	6 blossoms blasted 2 peaches injured 1 peach uninjured	No injury
Lygus sp.	All buds blasted	All but a few buds blasted	4 blossoms blasted 2 peaches injured None uninjured	4 blossoms blasted 6 peaches injured 6 peaches uninjured	No injury

The first dust was applied when the buds started showing pink. The second application was made directly after petal fall and the last dust was put on at shuck

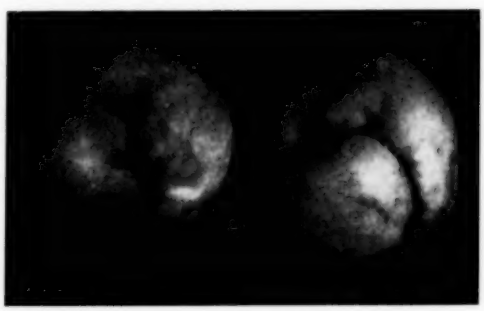

FIG. 2.—"Cat-Facing" of peaches caused by *Lygus* (Courtesy Colorado Bureau of Plant and Insect Control).

fall. Two sheets, 30 by 30 feet, were spread out beneath the trees to catch insects knocked down from the trees. Table 2 shows the insects knocked down from two trees.

Table 2.—Insects knocked down from two dusted trees.

APPLICATION	*Lygus*	VARIEGATED CUTWORMS
1st	6	55
2nd	2	5
3rd	0	2

The catch of cutworms on the sheet indicated that they might be a factor in the "monkey-facing" of the fruit. It should also be noted that no *Lygus* were found on the sheet after the last dusting. This fact substantiates the findings in the cage tests. The bugs do not attack the fruit after shuck fall. The third dust was probably not necessary.

Lygus injury was 1 per cent or less on all varieties except Golden Jubilee and Mayflower. The Mayflower is notorious for being the most severely infested with *Lygus*. The previous year this variety had about 90 per cent injured fruit.

There were no check plots in this experiment because of the migratory habits of the *Lygus*. Another untreated peach orchard nearby was checked for injury and showed about 55 per cent injured fruit on the total crop. This orchard had only two varieties, Hale and Elberta.

SUMMARY.—There are three species of *Lygus* that cause "cat-facing" or "monkey-facing" of peaches in the Wenatchee area. They are *L. elisus* Van D., *L. hesperus* var. *viridiscutatus* Kngt. and *Lygus* sp.

A pyrethrum dust, known as *Pyrocide Dust*, was found to be very effective in preventing injury to peaches by *Lygus* and cutworms.

Table 3.—Fruit injured by *Lygus* and cutworms in dusted orchard.

VARIETY	TREES COUNTED	TOTAL PEACHES INCLUDING THINNINGS	PEACHES PICKED	TOTAL FRUITS INJURED BY LYGUS	TOTAL FRUITS INJURED BY CUTWORMS	PICKED CROP INJURED BY LYGUS
Mayflower	1	2062	692	5.5%	2.5%	10.3%
Golden Jubilee	1	421	115	2.1	2.8	1.7
Hale	5	5623	2706	1.1	0.5	0.4
Improved Early Elberta	5	5625	3137	2.1	0.8	1.0
Elberta (Old)	5	4413	3402	0.7	0.3	0.4
Slappy	5	3812	3422	1.1	0.5	0.7
June Elberta	2	6702	760	1.1	0.6	0.0
July Elberta	1	2342	994	2.0	0.3	0.9
Elberta	5	3155	2375	0.6	0.2	0.5

Table 3 gives the percentage of control, both on the picked crop and the total crop, which included the thinnings. The fruit injured by cutworms was all removed at thinning time. It may be seen that the amount of injury by the cutworms was negligible on all the varieties except Golden Jubilee and Mayflower; it was only about 2.5 per cent on these varieties.

Three dusts containing 0.2 per cent pyrethrins were applied. The first dust was applied when the buds were in the pink stage. The second dust was applied just after petal fall and the third dust was applied after shuck fall.

The picked crop was 98.3 per cent free from *Lygus* injury, including all varieties of peaches.—12-1-40.

According to the *American Nurseryman* of October 15, 1940, the Texas Commissioner of Agriculture established a quarantine on October 1, 1940, on the azalea flower-spot disease, requiring special sanitation measures and the treatment of all azaleas shipped from Alabama, Florida, Georgia, Louisiana, Mississippi, North Carolina, South Carolina, and the Texas Counties of Harris and Galveston.

Field Spraying for Control of Grapeberry Moth[1,2]

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Various factors during the past several years have resulted in less spraying with a consequent upsurge of damage by grapeberry moth (*Polychrosis viteana* Clems), in the commercial grapegrowing area of Michigan. The low price of grapes, the residue tolerance, and lowered productivity may be cited as examples of the discouraging factors. Reports indicate a similar condition in other eastern grape-growing states.

The Van Buren County grape-growing area of Michigan is a continuation of the grape belt extending around the Great Lakes through the states of New York, Pennsylvania, Ohio and Michigan. The soil is predominantly sandy in nature and there is little variation in elevation in the grape-growing parts of the area. This condition, together with proximity to Lake Michigan, the lake lying not more than about 20 miles west of the farthest corner of the district, tempers the climate in such a way as to cause little yearly variation in the development of grapes or in the life history of the grapeberry moth over the area. In other words, grapes bloom over this entire area from June 7th to 15 year after year, while temperatures prior to the blooming time are such that the peak hatching of first brood grapeberry moth occurs just at, or slightly after, full bloom. In fact, practically all grape growers recognize and discuss the typical webbing of, and feeding in clusters by, the grapeberry moth just at and just after grape bloom, because it results in ragged bunches. This type of injury cannot be accurately measured and does not appear in the final counts, but must be considered in any spraying program.

Clean cultivation is practiced throughout the area, although but few growers cultivate in such a way as to influence markedly the population of berry moth. Practically all grapes are trained to the four-cane Kniffin system.

THEORY AND OBJECTIVES.—Observations within the Michigan grape belt over a period of years have indicated the apparent magnitude and severity of the first brood activity of grapeberry moth. It, therefore, appears than an effective spraying program should hit hard against the primary attack of the larvae. This is logical because, as already noted, the webbing and feeding are conspicuous and indicate the presence of the insect when it is in a vulnerable position, and it follows, too, that the second brood, being the offspring of the first, will be reduced by first brood control. The presence of grapeberry moth larvae at a time when necessary protection against fungous diseases must be provided brings attention to the question of compatibility of spray materials, to the necessity for heavy initial deposits of poison and to the danger of excessive residues. Concurrently with grapeberry moth control, grape leafhopper must be considered. All these things must be rationalized into an effective program, leaving the grower a profit despite the economic hedge of low returns. Development of the fixed nicotines and their demonstrated efficiency, alone and with summer oil, against certain fruit-infesting insects has been almost the only new factor introduced since the last of the earlier investigations in the same area.

As a result, the experimental spraying programs applied during 1939 and 1940 to selected vineyards in this area were designed to answer the following pressing questions: Is it possible to control grapeberry moth and leafhopper in this area by spraying? What is the arsenical to use? And is it possible to secure control of grapeberry moth and leafhopper through the use of a fixed nicotine program?

METHODS OF STUDY.—Identical experimental set-ups were made in two different vineyards each year because of the possibility of hail damage preventing the taking of representative results. Experimental set-ups were made only in vineyards having medium to heavy infestations and where reasonably good cultural practices were followed.

The four outside rows and the ends of the rows were excluded from the experimental set-up each year. The outside rows were heavily sprayed with oil, 3 quarts, and 40 per cent nicotine sulphate

[1] Early publication of this paper has been secured by the payment of the costs of printing.

[2] Journal article No. 509 (M.S.) from Michigan Agr. Expt. Sta.

three-quarters pint to 100 gallons, in addition to a heavy lead schedule.

Plots were laid out in triplicate in each set-up; each plot consisting of four rows the length of the field. Inasmuch as the rows were 10 feet apart and ranged from 50 to 90 vines in length, there were from 200 to 350 vines in each plot. Since there are approximately 540 vines to the acre when planted 8 ft. by 10 ft., each plot consisted of from slightly under to somewhat, over one-half acre. In each series of plots then, for each year, between one and one-half and two acres of grapes were sprayed with a given schedule.

Throughout the area the incidence of black rot and deadarm are such as to necessitate heavy spraying for their control; consequently, all applications of arsenical poisons were made in 8-8-100 bordeaux. Nicotine sulphate, when used for leafhopper, was applied in a 4-4-100 bordeaux, to avoid excessive staining by heavier bordeaux. The large quantity of solids in such mixtures necessitated the 3 quart dosage of oil in the schedules listed. *Black Leaf Concentrate* is incompatible with bordeaux and in schedules using this material a low soluble proprietary copper fungicide, with *Dreft*, as a spreader was substituted. This was used with nicotine compounds at the rate of 2 ounces per 100 gallons of spray, when no fungicide was used and increased to 4 ounces when copper was included. Cuprous cyanide was used without a fungicide.

Sprays were applied with modern machinery (Fig. 1), the pressure ranging from 400 to 600 pounds. From 125 to 250 gallons of material were used per acre per application, the average being in the neighborhood of 175 gallons per application per acre through the season. The only departure from orthodox vineyard spraying procedure was the employment of a covered, inverted, U-shaped boom carrying four nozzles on each side of the row and so arranged that the spray from the nozzles was directed upward and into the foliage of the vines. This arrangement permitted spraying in windy weather, made the most efficient use of the spray applied, and insured thorough coverage through confinement of the fog of spray delivered by the nozzles.

The spray schedule was as follows:

1. When the shoots were four to six inches long.
2. Just before bloom.
3. Just after bloom.
4. 7 to 10 days after 3.
5. 7 to 10 days after 4.

The result of this schedule was to force a large part of the insecticidal spraying into a period of approximately three weeks.

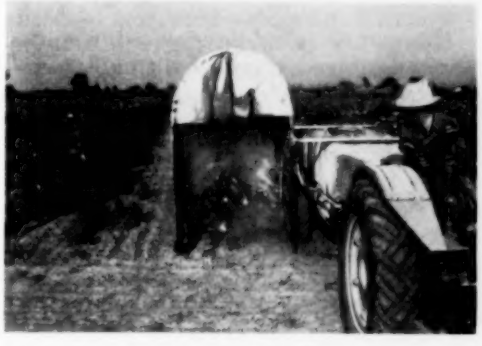

FIG. 1.—Spray outfit employed for application of the various mixtures.

Additional sprays were applied, as indicated in the schedules listed, as a result of field observations in 1939, on clusters webbed by larvae.

Information on brood development was kept up to date by daily inspection of bait pots strategically located at five points in the grape belt. The attractive substance used was a fermenting mixture of one-third pint *Br'er Rabbit* molasses, 15 drops sassafras oil, and water to make one quart.

Control results are expressed as percentage of clean grapes. In checking, 100 bunches of grapes were taken from each plot just before harvest by picking, at random, bunches from upper and lower wires alternately at regularly spaced intervals along the rows. Omitting, the ends of the rows and allowing for the length of the rows, this gave approximately one bunch of grapes from each five vines. The berries were stripped from the stems, scored, and the percentages computed. This arrangement necessitated counting the grapes from 300 bunches from each treatment in each experimental set-up each year. Tabulated results present an arithmetical average of results from the three replicates in each of the two series of plots. This presentation was adopted because results from the two experimental set-ups paralleled each other closely each year.

DATA AND RESULTS.—As has already been suggested, few insecticidal developments applicable to the control of grapeberry moth and grape leafhopper have been reported since arsenicals and 40 per cent nicotine sulphate were adapted to this use some years ago. Cuprous cyanide and fixed nicotines, with and without oil, seemed sufficiently promising to warrant trial.

The various schedules devised from the materials named, together with other substances usually referred to as adjuvants, *i.e.*, oil, casein-lime and *Dreft* are shown in tables 1 and 2.

Table 1.—Spraying data and results secured from several treatments for control of grapeberry moth in 1939.

SCHEDULE AND APPLICATION	SPRAY MIXTURE	CLEAN GRAPES PER CENT
1—1	Lead arsenate 3 lbs. and Oil 3 qts.	95.1
1—2	Lead arsenate 2 lbs. and Oil 3 qts.	
1—3	Lead arsenate 2 lbs. and Casein-lime 1 lb.	
1—4	Lead arsenate 2 lbs. and Casein-lime 1 lb.	
1—5	40% nicotine sulphate 1 pint, and *Dreft*, 4 oz.	
2—1	Lead arsenate 3 lbs and Oil 3 qts. plus 40% nicotine sulfate ½ pint	99.1
2—2	Same as number 1	
2—3	Lead arsenate 2 lbs. plus 40% nicotine sulfate ½ pint and Oil 3 quarts	
2—4	Same as No. 3	
2—5	40% nicotine sulphate ½ pint and Oil 3 quarts	
3—1	Lead arsenate 3 lbs. and Oil, 3 qts.	95.5
3—2	Same as No 1	
3—3	Cuprous cyanide (*Kutane*) 4 lbs.	
3—4	Same as No. 3	
3—5	40% nicotine sulphate, 1 pint and *Dreft*, 2 oz.	
4—1	Lead arsenate 3 lbs. and Oil 3 qts.	98.8
4—1-a	Same as No. 1	
4—2	Lead arsenate 2 lbs. and Oil, 3 qts.	
4—3	40% nicotine sulphate 1 pint, and Oil, 3 qts.	
4—4	Same as No. 3	
4—5	*Black Leaf Concentrate* (14%) 3 lbs.	
5—1	Lead arsenate 3 lbs and Oil, 3 qts.	98.9
5—2	Same as No. 1	
5—3	Lead arsenate 2 lbs. and Casein-lime 1 lb.	
5—4	*Black Leaf Concentrate* (14%) 3 lbs.	
5—5	Same as No. 4	
6—1	Lead arsenate 3 lbs. and Oil, 3 qts.	98.7
6—2	Same as No. 1	
6—3	Lead arsenate 2 lbs. and Casein-lime 1 lb.	
6—4	*Black Leaf Concentrate* (14%) 3 lbs.	
6—5	Same as No. 4	
6—5-a	Same as No. 4	
7—1	Lead arsenate 3 lbs. and Oil, 3 qts.	97.9
7—1-a	Calcium arsenate 3 lbs. and Oil, 3 qts.	
7—2	Calcium arsenate 2 lbs. and Oil, 3 qts.	
7—3	40% nicotine sulphate 1 pint and Oil, 3 qts.	
7—4	40% nicotine sulphate 1 pint and Oil, 3 qts.	
7—5	*Black Leaf Concentrate* (14%) 3 lbs.	
8—1	Calcium arsenate 3 lbs. and Oil, 3 qts.	98.7
8—2	Same as No. 1	
8—3	Calcium arsenate 2 lbs. and Oil, 3 qts.	
8—4	Same as No. 3	
8—5	40% nicotine sulfate 1 pint, and *Dreft*, 4 oz.	

Application 1-a in schedules 4 and 7 was inserted in an effort to control larvae in webs on clusters. Application 5—2 in Schedule 6 was applied 8 days after 5.

Table 2.—Spraying data and results secured from several treatments for control of grapeberry moth in 1940.

SCHEDULE AND APPLICATION	SPRAY MIXTURE	CLEAN GRAPES PER CENT
9—1	Calcium arsenate 3 lbs. and Oil, 3 qts.	98.9
9—2	Same as No. 1	
9—3	Same as No. 1	
9—4	Calcium arsenate 2 lbs. and *Dreft*, 4 oz.	
9—5	40% nicotine sulphate, 1 pint, and *Dreft*, 4 oz.	
10—1	Calcium arsenate 3 lbs. and Oil 3 qts.	95.4
10—2	Same as No. 1	
10—3	Cuprous cyanide (*Kutane*) 4 lbs.	
10—4	Same as No. 3	
10—5	40% nicotine sulphate, 1 pint, and *Dreft*, 2 oz.	
11—1	Calcium arsenate 3 lbs. and Oil, 3 qts.	99.3
11—2	Same as No. 1	
11—3	Same as No. 1	
11—4	*Black Leaf Concentrate* (14%) 3 lbs. and *Dreft*, 4 oz.	
11—5	Same as No. 4	
12—1	Calcium arsenate 3 lbs. and Oil, 3 qts.	98.6
12—2	Calcium arsenate 2 lbs. and Oil, 3 qts.	
12—3	*Black Leaf Concentrate* (14%) and *Dreft*, 4 oz.	
12—4	Same as No. 3	
12—5	Same as No. 3	
13—1	Calcium arsenate 3 lbs. and Oil, 3 qts.	97.3
13—2	*Black Leaf Concentrate* (14%) and *Dreft*, 4 oz.	
13—3	Same as No. 2	
13—4	Same as No. 2	
13—5	Same as No. 2	

Analyses of residues in both 1939 and 1940 by the Experiment Station Chemist indicated less than the established tolerances. Oil used was in all cases *Orthol-K* summer oil.

Leafhopper control effected by these schedules was satisfactory. Schedules 6, 11, 12, and 13, having two or more sprays of *Black Leaf Concentrate* for grapeberry moth, showed as few leafhoppers as the rest of the plots which had received applications of 40 per cent nicotine sulphate, the regular recommendation for leafhoppers.

DISCUSSION.—In considering the results attained in the two years field experimentation detailed, the progressive nature of the undertaking must be appreciated. Some of the schedules, 2 and 7, for example, were undertaken solely for evaluation of certain insecticides and their place in the general scheme. It should be kept in mind also that a workable spraying program for control of berrymoth and leafhopper was the ultimate aim. Information on control, timing, compatibilities, staining, residue, and effectiveness gained from the application of schedules 1 to 8 was embodied in the formulation of schedules 9 to 13. Schedules 9 to 13, may be regarded as verifying the more apparent conclusions regarding schedules 1 to 8. These are that calcium arsenate, when used in the same way, is as effective as

lead arsenate against grapeberry moth; that fixed nicotine offers an alternative and effective material for use against grapeberry moth; that fixed nicotine when used against grapeberry moth in enough applications to influence noticeably the control of grapeberry moth larvae, effectively controls the leafhopper. In addition to verification of the conclusions from the control afforded by schedules 1 to 8 inclusive, schedules 9, 11, 12, and 13 may be cited as answering, in so far as two years experience can answer, the queries propounded under "Theory and Objectives." Degrees of control of grapeberry moth afforded by schedules 9, 11, 12 and 13 are not considered significantly different; however, by the converse of this reasoning, the differences in effectiveness of single applications of calcium arsenate and of *Black Leaf Concentrate* are not significantly different.

It would seem, then, that a split schedule consisting of two sprays calcium arsenate, 3 pounds per 100 gallons before bloom; one similar spray after bloom and at least two sprays of *Black Leaf Concentrate*, 3 pounds per 100 gallons, offers an excellent insecticide program for the control of grapeberry moth and grape leafhopper under the conditions which existed during the two seasons of experimentation, within the Michigan commercial grape-growing area.

Observations upon the effect of the various materials listed as adjuvants lead to the conclusion that their value is chiefly as wetting agents, increasing the penetration of sprays into the webs of clusters. Inspection of the tabulated data indicates that unless some such material is present in spray No. 3, applied just after bloom, the percentage of clean grapes drops.

The effective schedules presented, it will be remembered, are telescoped into a space comprising the blooming period and about two weeks thereafter. From this fact it would seem that one of the reasons for their effectiveness lies in their influence upon survival of grapeberry moth larvae of the first brood, which are, as already noted, numerous and noticeable in their webs on the clusters at blooming period and immediately thereafter.

Cuprous cyanide, included because grapes are tolerant to copper and in the hope that it might serve as an accessory fungicide because of its slow liberation of soluble copper, while controlling grapeberry moth, was very interesting. The material was used without a sticker and performed just as well as lead arsenate (Schedule 1). Good berrymoth and fungus control with this material is a reasonable possibility if a suitable accessory material to carry it into the webs can be found. However, the application of a special leafhopper spray will be necessary with such a schedule.

SUMMARY.—The conditions obtaining in the Michigan grape growing belt, *i.e.* an early, heavy first brood attack by grapeberry moth at blooming time, apparently necessitate heavy spraying at that time for good control. The spray schedules which can then be applied profitably are somewhat restricted by the necessity for heavy spraying with bordeaux, which is incompatible with some of the possibly effective materials. The low-soluble proprietary coppers offer a partial solution of the problem, since some of these materials are compatible with effective materials.

Lead and calcium arsenates are equally effective against grapeberry moth. *Black Leaf Concentrate* can be substituted for the arsenicals, with equal or better results.

A split schedule consisting of two sprays of an arsenical with oil before and one just after bloom and at least two additional sprays of *Black Leaf Concentrate* will control grapeberry moth and leafhoppers at the same time. Under the experimental conditions, the presence of a good wetting agent seems necessary in the applications at blooming time to assure their penetration into the webs in the clusters.

Telescoping the major portion of the spraying program into a period while the grapes are small, apparently cuts down the possibility of excessive residue at harvest.—1-7-41.

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A Study of Clays Used in Preparation of Tank-Mix Nicotine Bentonite Sprays

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The first insecticidal use of bentonite with nicotine was as a presumably inert carrier for nicotine in dusts. It was not satisfactory for this purpose because it inhibited the volatilization of the nicotine. Rudolfs (1922) found that colloidal carriers (such as bentonite) released nicotine less rapidly than crystalloidal carriers. Harlan & Hixon (1928), studying nicotine bentonite dusts, obtained information that would indicate a chemical union between nicotine and bentonite. C. R. Smith (1934) recognized that the reaction between bentonite and salts of organic bases was one of base exchange and applied for patents (issued in 1936 and 1937) for a nicotine bentonite insecticide and processes of manufacture. Since 1934 there has been a general interest in the use of bentonite to "fix" nicotine. A factory-processed nicotine bentonite has been manufactured for codling moth control, and various workers, Driggers & Pepper (1934), Steiner & Sazama (1938), and others, have published the results of studies of "tank-mix" nicotine bentonite sprays. Throughout the works mentioned it has been specifically stated or implied that Wyoming type bentonite was used and that other bentonites had not been tested as fixators for nicotine.

Table 1.—Swelling and flocculation properties of bentonite clays and other carriers and their reaction with nicotine sulfate.

Bentonite or other carrier[1]	Swelling value	Flocculated by nicotine	Nicotine removed from water solution
	Ml. per gram		*Per cent*
Wyoming A	11.0	Yes	94.0
Fused sulfur bentonite	5.0	Yes	93.1
Mississippi	2.9	No	93.1
Wyoming C	8.25	Yes	92.7
Eastern Wyoming	9.0	Yes	92.7
Black Hills	8.2	Yes	91.9
Wyoming D	8.0	Yes	90.2
Wyoming B	9.5	Yes	89.9
South Dakota	7.0	Yes	84.4
Arkansas A	2.0	No	83.5
California A	.5	No	83.4
British Columbia A	1.9	No	81.3
Arkansas B	1.5	No	81.2
Alberta	4.2	Yes	81.1
Colorado	.5	No	75.5
California B	7.0	Yes	74.7
Florida B	.0	No	72.0
Georgia	1.0	No	62.6
British Columbia B	4.75	Yes	62.1
Fuller's earth	0.0	No	46.9
Florida	0.0	No	38.7
Texas	.5	No	23.5
Talc	0.0	No	22.0
Zeolite	0.0	No	16.0
Kaolin	0.0	No	3.1
Wood charcoal	0.0	No	2.7
Silica clay, Washington	0.0	No	2.3

[1] Bentonite clays are designated by their origin, followed by letters where several came from the same source.

Bentonites are soapy clays of weathered and altered volcanic ash which occur in practically all formations of volcanic origin. It is the purpose of this paper to discuss the use of bentonite clays originating in several geographic regions of the United States and Canada as fixators for nicotine and in the preparation of codling moth sprays.

Bentonite clays were obtained from 11 states of the United States and 2 Canadian provinces. In addition several materials, such as fuller's earth, kaolin, and activated carbon, which are used as carriers for nicotine were included in the studies. The results of experiments conducted with these materials are tabulated in table 1.

SWELLING VALUE.—Bentonite clays originating in the Black Hills area of South Dakota and Wyoming possess a peculiar property of swelling when wetted with water. To measure the swelling property, the volume of 1 gram of dry clay was determined in a 5-ml. graduate, the sample was transferred to a 25-ml. graduate and covered with water, and its volume read at 24-hour intervals. The swelling was considered complete when there was no change in volume over a 48-hour period. The difference between the volume when dry and when saturated with water was termed the "swelling value."

Eleven of the materials showed a swelling value greater than 4. Seven of these materials originated in Wyoming and South Dakota one each in California, British Columbia and Alberta and one was a sulfur-bentonite auxiliary spray material. None of the other materials swelled appreciably when wetted.

FLOCCULATION OF CLAY SUSPENSION.—Smith (1934) states that if the salt of an organic base flocculates a bentonite suspension, the organic base reacts well with bentonite. If the converse of this is true,

any clay that is flocculated from suspension by nicotine sulfate would react well with the nicotine sulfate. Suspensions of 5 gms. of clay in 100 ml. of distilled water were prepared, to each of which was added 100 ml. of distilled water containing 1 gm. of commercial nicotine sulfate solution (40 per cent nicotine).

Only those clays that had swelling values greater than 4 were flocculated by the nicotine sulfate.

Smith[1] suggests that the swelling power of bentonites with high combining power for nicotine varies because of variations in the natural flocculating agents present, such as ferric and aluminum hydroxide hydro gels, organic matter, and similar colloidal material. When Mississippi bentonites are treated with dilute mineral acids, some of the natural flocculants are removed, so that fine suspensions can be made which act in the same way as the Wyoming bentonites. Organic proteins, such as gelatin, casein, and others, flocculate bentonite suspensions with little or no loss in combining power for nicotine. This is probably true for many other hydrogels.

NICOTINE COMBINING POWER.—The value of bentonite in nicotine spray mixtures depends upon its power to remove the nicotine from water solution to form an insoluble compound. This reaction is not quantitative but reaches an equilibrium based on the concentrations of nicotine and bentonite. The quantity of nicotine removed from water suspension was determined by placing 5 gms. of bentonite and 1 gm. of commercial nicotine sulfate solution (40 per cent nicotine) in 200 ml. of water.

In table 1 the materials have been arranged in order of the quantity of nicotine removed from water solution. The first 9 materials removed 84.4 per cent or more of the nicotine. All except the Mississippi bentonite had swelling values greater than 5 and were flocculated from suspension by the nicotine sulfate. The next 10 materials removed from 62.1 to 83.5 per cent of the nicotine. Three of these materials were flocculated from suspension by nicotine sulfate and had swelling values greater than 4. The last 8 materials removed less than 50 per cent of the nicotine, did not show any appreciable swelling when wetted with water, and were not flocculated from suspension by nicotine sulfate.

LABORATORY SPRAYING TESTS.—Five of the clays from the foregoing group were selected for laboratory spraying tests. Wyoming clays A and B were selected as typical of Wyoming bentonites which removed, respectively, the greatest and smallest quantities of nicotine from water solution. The South Dakota clay was used because of its pronounced swelling and flocculation and the small quantity of nicotine it removed from water solution. The Mississippi and Colorado clays represented non-swelling clays that removed a large part of the nicotine from water suspension. These clays were used to prepare spray mixtures of the tank-mix nicotine bentonite type described by Steiner & Sazama (1938).

Lots of 120 fruits each were sprayed with each mixture, and when they were dry 40 fruits were taken from each lot for chemical analysis to determine the residue resulting from a single application. The remaining 80 fruits of each lot were sprayed a second time and allowed to dry; after the second application 40 fruits were analyzed to show the total residue deposited by two spray applications. The remaining 40 fruits were then washed with a spray of fresh water (to simulate weathering by rainfall) and, when dry, were analyzed to determine the quantity of residue lost by weathering. The data from these analyses are given in table 2.

Table 2.—Spraying tests with tank-mix nicotine bentonite spray mixtures containing various types of bentonite.

BENTONITE	NICOTINE SPRAY RESIDUE DEPOSIT, IN MICROGRAMS PER SQUARE CENTIMETER			RESIDUE LOST IN WEATHERING PER CENT	TYPE OF COVERAGE
	After first spray	After two sprays	After weathering		
Wyoming A	4.34	10.52	7.59	27.9	Blotch
Wyoming B	3.78	8.22	5.98	27.3	Blotch
South Dakota	3.02	6.66	4.90	26.4	Blotch
Mississippi	2.36	4.62	3.07	33.5	Spot
Colorado	2.40	4.26	2.83	33.6	Spot

These data show that the greater the quantity of nicotine removed from solution by the bentonite the greater will be the deposit resulting from a spray application. They also show that those materials that were flocculated by the nicotine sulfate deposited a blotch-type (large, irregular-shaped residue-covered areas) residue which resisted weathering to greater de-

[1] Private communication.

gree than those materials that were not flocculated by the nicotine sulfate and deposited a spot-type (dried droplets in approximately symmetrical form) residue.

CONCLUSIONS.—It is evident that many of the clays used in these tests would not be satisfactory for the preparation of tank-mix nicotine bentonite sprays. Bentonite clays satisfactory for use in the preparation of such sprays should possess the following properties:

(1) When wet with water they should swell to the extent of at least 4 milliliters per gram of clay.

(2) They should be flocculated from water suspension by the addition of 1 gram of commercial nicotine sulfate solution (40 per cent nicotine) to each 5 grams of clay.

(3) They should remove not less than 90 per cent of the nicotine from water solution when mixed in the proportion of 1 gram of commercial nicotine sulfate solution (40 per cent nicotine) to 5 grams of clay.

Clays that are not flocculated by the addition of nicotine sulfate to a suspension of the clay are not satisfactory for the preparation of tank-mix nicotine bentonite sprays.

There are some bentonites that swell when wet with water and are flocculated by the addition of nicotine sulfate to water suspensions but do not remove 90 per cent of the nicotine from water solution. These clays can be used, but they are less satisfactory than those bentonites that remove more nicotine from water solution.

SUMMARY.—Twenty-seven bentonite clays obtained from 11 states and 2 Canadian provinces were studied along with seven other absorbent materials to determine their value in the preparation of nicotine bentonite sprays. Tests were made to determine their swelling value, whether or not suspensionsprepared from them were flocculated by the addition of nicotine sulfate, and the quantity of nicotine removed by them from water solution.

In general those clays that removed a high percentage of nicotine from water solution showed characteristic swelling when wet with water and were flocculated from water suspension by the addition of nicotine sulfate. The principal exception was a bentonite obtained from Mississippi which did not swell when wet with water and was not flocculated by the addition of nicotine sulfate but did remove 93.1 per cent of the nicotine from water solution.

Spraying tests showed that the residues resulting from clays flocculated by nicotine sulfate were blotchy in character and more resistant to weathering than the spot-type residues deposited by clays that were not flocculated by nicotine sulfate. —12-31-40.

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Quarantine No. 4 of the State of Arizona, which pertains to scale insects, mealybugs, and white flies, was reissued November 14, 1940. Eleven species of plants have been dropped from the long list of designated hosts, while Bamboo, Cistus, Lantana, and Spindletree have been added to this list. Host plants arriving at the Arizona border are required to be held for inspection unless they are certified as having been fumigated at point of origin. No change is made in the list of 12 states designated as subjects to quarantine because of infestation with these pests.

Orchard Observations of the Emergence of Codling Moths from Two-Year-Old Larvae

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It is generally supposed that overwintering larvae of the codling moth, *Carpocapsa pomonella* (L.), usually transform to moths during the spring and early summer of the season immediately following hibernation, although there are a few records in the literature that suggest that some of them may carry over until the second season.

Hammar (1912) reported that, of two larvae that cocooned in 1908 but failed to transform in 1909 and were placed in a vial, one pupated the following April but died and the other died in June. Longley (1921) reported that previous season's larvae were found still showing no signs of pupation the first week in July. These larvae were below the soil surface and protected from the heat by a mat of grass. Siegler & Brown (1928) referred to Hammar's observation and reported the following test: In the late fall of 1925, 2,306 larvae were collected in pupation sticks; they were kept until the following March in an outdoor insectary and then in cold storage at 32°F. until the following April. At that time only 68 larvae were alive and all but 2 were in a weak condition. One pupated but the moth failed to emerge.

Striking evidence that not all overwintering larvae transform the season after that in which they cocooned came to the writers' attention in 1939, in the Yakima district of Washington. In an orchard which had been heavily infested in 1938, and which in 1939 had many fruitless trees and others with only a bushel or so of apples, thousands of overwintering larvae were found still alive in their cocoons in the soil at or near the base of the trees, as late as November 10 (Table 1). All larvae were attached to the base of trees, from 1 to 3 inches beneath the soil surface, or in adjacent soil and debris not more than 4 inches from the tree trunks. The soil about the trees was mostly dry and dusty; some of it, however, was slightly moist. Larvae were found on all sides of the trees and in the adjacent soil.

The evidence that the non-transforming larvae were left over from the 1938 (or earlier) season is as follows: (1) They were first found, hundreds of them to a tree base, the first week in July, when scarcely any larvae had left the fruit,—practically none in this well-sprayed orchard. (2) Hundreds of these larvae to the tree were found on trees with only a dozen or so apples, and on one fruitless tree in the midst of nine other fruitless trees. (3) These larvae were white while the larvae of the current season were of a pinkish shade. (4) The cocoons were often in masses attached to one another and to the tree or to bits of debris, exactly like those masses of cocoons from which spring-brood moths had emerged about the bases of similar trees nearby during the spring and early summer. (5) The cocoons were tough and weathered.

Table 1.—Number of old (1938) and new (1939) codling moth larvae found attached to the base of apple trees, 1 to 3 inches below the soil surface or in the adjacent soil within 4 inches of the tree, Yakima, Wash., 1939.

Tree No.	Date Examined	Number of Old Larvae	Number of New Larvae	Remarks
1	July 6	32	0	Some of these trees had more or less of a crop of apples, but very few larvae had left the fruit.
2	July 6	132	0	
3	July 24	90	1	
4	July 26	51	1	
5	July 26	201	3	
6	Aug. 7	55	0	
7	Aug. 7	438	0	No emergence holes in the 8 apples on this tree.
8	Aug. 16	139	3	Five days after this examination the fruit of this tree had 27 exit holes.
9	Aug. 30	348	36	This tree produced several boxes of fruit, from which the new larvae came.
10	Sept. 15	491	0	Neither this tree nor any of the 9 nearest it had any fruit to speak of.
11	Nov. 10	150	2	Practically no crop.

The observations were continued into the second year, until August 9, 1940. Three of the infested tree trunks (lot 1) were surrounded with wire-screen cages (Fig. 1) August 9, 1939. Two of these trees (Nos. 1 and 3) had no crops, and one (No. 2) had about 4 bushels of apples showing 57 holes from which larvae had emerged. All of this crop was removed when the

cages were built. On September 29, 21 moths had emerged from cage No. 1, 19 from cage No. 2, and 5 from cage No. 3. In 1940 the soil in these cages was examined for empty pupal cases every 3 or 4 days. Another lot of three trees (lot 2),

FIG. 1.—Screen cage in position about apple tree trunk for observations on emergence of hibernating codling moth larvae.

practically fruitless in 1939, was similarly examined from May 3 to June 18, 1940, when cages were built around their bases to prevent entrance of any 1940 larvae, and then examined frequently until August 9. Four other trees (lot 3) that were left exposed to 1940 larvae were examined also until August 9. A summary of the emergence records for the three lots is given in table 2.

In the three lots a total of 989 moths emerged in 1940 from the trees under observation. Of these all but about 100 must have come from larvae of the 1938 season.

This furnishes substantial proof that some healthy hibernating codling moth larvae may fail to transform the season following hibernation, and may, under certain conditions, transform to moths two seasons later. No evidence was obtained as to whether larvae may survive more than two dormant seasons.

These facts are of considerable importance in the matter of control. It has been generally believed that the codling moth cannot survive a cropless season, and that a natural or artificial removal of the crop would entirely eliminate the insect in a given orchard or district. According to the foregoing evidence, however, a complete eradication cannot be expected even from the total absence of a crop for a single season, because of this two-season survival of some of the hibernating larvae.—1-2-41.

Table 2.—Emergence of codling moths in 1940 from larvae that hibernated in 1938. Hunzicker orchard, Yakima, Wash.

Lot 1—Cages Built About Tree Trunks August 9, 1939		Lot 2—Cages Built About Tree Trunks June 18, 1940		Lot 3—Unprotected Tree	
Tree No.	Number of moths	Tree No.	Number of moths	Tree No.	Number of moths
1	144	1	194*	2	25
2	116	4	56	3	77
3	165	6	81	5	83
				7	48
Totals	425		331		233

* Many other cocoons were torn open and the larvae destroyed by birds or mice before the cage was built.

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Arrangements are being made to have mimeographed copies made of certain discussions of problems of quarantine administration and inspection which occurred in the meetings of the Section of Plant Quarantine and Inspection during the Annual Meetings at Philadelphia.

Interested members may secure further information concerning these from Mr. Roy G. Richmond of the Bureau of Entomology and Plant Quarantine.

The Bureau of Entomology and Plant Quarantine of the State Department of Agriculture of California has promulgated regulations, Q. C. circular No. 100, governing the movement of grapevines, cuttings, and other propagative material of the grape because of Pierce's disease. The regulation was adopted December 30, 1940, to be effective during the winter shipping season and extending through the spring of 1941, and is designed for the protection of areas not now known to be infected.

Control of Pacific Mite and European Red Mite on Apples[1]

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The Pacific mite, *Tetranychus pacificus* McG., probably causes more damage to apples in Washington than does any other pest. Unlike the codling moth, it damages not only the fruit but also injures the tree. The mite feeds by thrusting the lance-like mouth parts into the leaf and extracting plant juices and chlorophyll. The leaves become bronzed and infested orchards take on a characteristic appearance, readily apparent even from a considerable distance, Where infestations are heavy there is more or less defoliation, the fruit fails to color properly and there is usually a heavy fruit drop just before harvest time. Generally, a smaller crop is obtained the following year because the formation of fruit buds is prevented.

The damage caused by the European red mite, *Paratetranychus pilosus* Can. & Fanz., is similar to that caused by the Pacific mite but the European mite is not as prevalent and is somewhat easier to control because it does not spin a heavy web as the Pacific mite does.

Life History.—Pacific mites pass the winter as adult females under the rough bark of the trees or under leaves and trash on the ground.

In the spring they migrate up the tree trunks, beginning about the time the buds are showing green. This migration is commonly complete by the time the king buds are opening. In Wenatchee this is about the end of April. The mites feed on the new tender growth and begin laying eggs shortly after migrating. Each female lays an average of about fifty eggs. In hot, dry weather the Pacific mite reproduces very rapidly, completing the life cycle in about two weeks.

Infestations of more than a thousand mites per leaf are not uncommon. In such cases, the fruit is completely "cellophaned" with the webbing of the mites. Infestations are spread chiefly by mites travelling on wind currents, with the aid of strands of webbing. In the fall, when the nights turn cool and the rains begin, the adult female Pacific mites turn orange in color and spin down the trees on webs to seek overwintering quarters.

A study of the biology of the European red mite has been made by Newcomer & Yothers (1929). According to these authors the European red mite overwinters in the egg stage. The winter eggs are laid on the branches and twigs of the tree. In the Wenatchee district the eggs hatch in late April, just before the apple blossoms open. Hatching of all the eggs is usually completed in seven to ten days. The newly hatched larva begins feeding at once. In 3 to 8 days the six-legged larva molts and passes into the eight-legged protonymph stage. The protonymph molts again and becomes a deutonymph. The deutonymph molts and becomes the adult. The length of the protonymph and deutonymph stages combined is 5 to 10 days. About two days after emerging, the adult female begins to deposit eggs. Oviposition takes place during 9 to 11 days, each female laying an average of about 26 eggs. Six complete broods occur, with partial seventh and eighth broods. For the later broods the time intervals are somewhat shorter than given above. The life cycle of a single generation is completed in about 21 days.

Present Control Methods.—Although mites have been a serious pest on apples in Washington for many years, no satisfactory method of control has heretofore been found. Infestations, present in the early spring, are generally kept down by the regular codling-moth spray program; the sprays, applied under high pressure, wash some of mites off the trees. In July, when the codling-moth spray program tapers off, the mite infestations build up. At this time it is dangerous to use more than 0.75 per cent oil on the trees and this is not sufficient to kill both mites and eggs, for which about 1.5 per cent oil is necessary. The use of derris, with 0.5 to 0.75 per cent oil, increases the kill of mites somewhat, but does not kill the eggs; hence the infestation soon builds up again. Because of climatic conditions and the use of oil in codling-moth sprays, it is dangerous to use sulfur compounds for mite control in Washington.

Experiments with *Selocide* on Citrus and Grapes.—The material *Selocide* was first introduced for mite control in 1931.

[1] Early publication of this paper has been secured by payment of the costs of printing.

Briefly, it is made by dissolving selenium in potassium-ammonium sulfide solution (Gnadinger 1933). It has been used for the control of mites on citrus fruits and grapes since 1932. The first experiments on grapes and citrus were so promising that the Dean of the College of Agriculture, University of California, appointed a special committee[2] in 1934 to make a thorough study of the use of *Selocide* for the control of mites on citrus fruits and grapes.

The investigation was continued until 1937 and the results were published by

1. Its efficiency in killing mites and eggs.
2. The selenium residue problem.
3. Its compatibility with other spray materials.

Preliminary tests on European red mite, Pacific mite and their eggs gave satisfactory kills. Analyses of soils and fruit from orchards not sprayed with *Selocide* indicated that apples do not take up selenium from the soil. Accordingly a thorough investigation was planned to determine whether or not *Selocide* can be used on apples with the same degree of safety as on citrus fruits and grapes.

Table 1.—Effect of *Selocide* on mites and eggs and on selenium content of ripe apples.

Orchard	Sample No.	Location	Variety	Acres Sprayed	Date of Spray	Species of Mite	Kill: Mites and Eggs, Per Cent	Selenium Content of Fruit (p.p.m.)			Washing Treatment for Residue Removal
								Entire fruit	Flesh only	Core	
A	1	Ephrata	Jonathan	16	Apr. 10	European	99.9	0.01	0.06	—	None
						Pacific	99.9				
A	2	Ephrata	Delicious	16	Apr. 10	European	99.9	0.10	0.01	—	None
						Pacific	99.9				
B	9	Wenatchee	Jonathan	.1	May 30	None	—	0.45	0.20	0.16	None
B	10	Wenatchee	Jonathan	.1	July 5	None	—	0.18	0.13	—	Tandem[1]
B	11	Wenatchee	Jonathan	.1	Aug. 7	None	—	0.17	0.03	0.22	Tandem[2]
B	12	Wenatchee	Jonathan	.1	3 applications	None	—	0.26	0.09	0.31	Tandem[3]
B	13	Wenatchee	Jonathan	.1	None	None	—	0.53	0.15	0.11	None
B	14	Wenatchee	Delicious	.1	None	None	—	0.03	0.05	—	None
C	17	Okanogan	Winesap	90	July 16	Pacific	96.5	0.14	0.07	—	None
C	18	Okanogan	Winesap	90	July 16	Pacific	96.5	0.04	0.03	—	Single[4]
D	4	East Wenatchee	Delicious	4	Aug. 6	Pacific	93.2	0.17	0.08	—	None
D	3	East Wenatchee	Delicious	4	Aug. 6	Pacific	93.2	0.12	0.02	—	Tandem[5]
E	7	Monitor	Delicious	.5	Aug. 19	Pacific	97.7	0.02	0.03	—	None
E	8	Monitor	Delicious	.5	Aug. 19	Pacific	97.7	0.05	0.02	—	Tandem[5]
F	15	Brewster	Delicious	3	Aug. 20	Pacific	97.2	0.14	0.04	—	None
F	16	Brewster	Delicious	3	Aug. 20	Pacific	97.2	0.14	0.02	—	Tandem[6]
G	5	Sunnyslope	Delicious	.5	Aug. 21	Pacific	98.9	0.21	0.11	—	None
G	6	Sunnyslope	Delicious	.5	Aug. 21	Pacific	98.9	0.55	0.08	—	Tandem[7]

[1] 1% HCl, 90° F; 1% HCl, 90° F.
[2] 3% sodium silicate, 95° F; ½% HCl, 60° F.
[3] 9% sodium silicate, 102° F; 1% HCl, 82° F.
[4] 1.2% HCl, 61° F.
[5] 4.8% silicate, 60° F; 1% HCl 60° F.
[6] 4% silicate, 95° F; ½% HCl, 60° F.
[7] 9% silicate, 90° F; 1% HCl, 80° F.

the California Experiment Station (Hoskins *et al.* 1938). These investigators found that *Selocide* is effective for the control of mites on citrus and grapes and that proper use of the material on citrus and grapes, under the prevalent conditions of production in California, offers no hazard to public health.

EXPERIMENTS ON APPLES.—There are three problems involved in the use of *Selocide* for the control of mites on apples:

[2] The members of this committee were, Chairman, W. B. Herms, Head of the Division of Entomology and Parasitology; D. R. Hoagland, Head of Division of Plant Nutrition; C. D. Leake, Professor of Pharmacology; W. M. Hoskins, Associate Professor of Entomology; A. M. Boyce and J. F. Lamiman of the Dept. of Entomology, and P. L. Kirk of the Department of Chemistry, University of California.

TOXICITY TO THE MITES.—During 1939 *Selocide* was applied to 300 young Delicious trees at the Branch Station of Washington State Experiment Station, Wenatchee. These trees were 5 to 6 ft. high and were heavily infested with Pacific mite, averaging 700 mites and 200 eggs per leaf. The kill of mites was 99.5 per cent and of the eggs 99.2 per cent. There was no apparent injury to the young trees.

In the annual report of Washington Experiment Station, Webster & Moore (1939) reported that *Selocide* was the most effective material for the control of mites, among 34 different sprays tested in 1939.

In 1940, six heavily infested orchards in different parts of the Wenatchee-Okanogan valley were sprayed with *Selocide*. The applications were made to three varieties of apples at different stages of the growing season. Counts of mites and eggs were made before the spray was applied and at intervals of 10 to 25 days after the application. At harvest time, samples of fruit were taken from the trees which had been sprayed. Half of each sample was washed in a commercial washer, by one or more of the methods in commercial use for removing arsenic, lead and fluorine residues. The other half of the sample was not washed. The selenium content of the washed and unwashed fruit was determined by the method described by Hoskins (1938). Determinations of selenium were made on the entire fruit, on the peeled and cored fruit and, in some cases, on the cores.

The results of the 1940 experiments are summarized in table 1.

Orchard A had a history of severe Pacific mite and European red mite infestation extending over many years. This orchard was sprayed with *Selocide* April 10, when the king buds were just opening. The leaves were less than one inch long and there was an average of 2 Pacific mites and 2.5 European red mites per leaf. After spraying, counts were made at intervals of 21 days. The first two counts showed a kill of 99.9 per cent. Nine weeks after spraying there was an average of 0.2 Pacific mites per leaf and there were no European red mites; the length of the leaves had increased to more than three inches.

Selocide had no repellent effect on bees, and pollination proceeded normally.

The infestation did not build up again during the summer except in a few trees in outer rows, probably reinfested by wind-borne Pacific mites. No European red mites were found up to harvest time.

Orchard C, infested with Pacific mite, averaged about 150 mites and 200 eggs per leaf. After spraying on July 16, counts were made July 26, when the kill was found to be 96.5 per cent of mites and eggs. Later inspections showed no reinfestation up to harvest time, but near by orchards suffered heavy damage until harvest.

In Orchard D there were 118 Pacific mites and 300 to 400 eggs per leaf. The kill of mites and eggs was 93.2 per cent ten days after spraying. This orchard consisted of Delicious apples interplanted with apricots which were also infested with mites. The apricots were not sprayed and high winds prevailing for five days prior to the final count probably reinfested the apples to some extent.

Orchard D was sprayed when the temperature was 105° F. There was some leaf-drop from lower branches which were practically touching the white, sandy soil. Otherwise the trees and fruit were not injured.

In Orchard E there were 104 Pacific mites and about 200 eggs per leaf. Counts made 11 days after spraying showed 97.7 per cent kill of mites and eggs. There was no injury to fruit or trees. There was no build-up of the infestation after spraying.

The infestation of Pacific mites in Orchard F averaged 110 mites and about 100 eggs per leaf. Counts made eleven days after spraying with *Selocide* showed 97.2 per cent kill of mites and eggs. There was no reinfestation and no injury to trees or fruit.

Orchard G was infested with about 98 Pacific mites and 150 eggs per leaf. Ten days after spraying there was an average of 1 mite per leaf, a kill of 98.9 per cent of mites and eggs, with no injury to fruit or trees.

In general the foliage of trees sprayed with *Selocide* became deeper green in color and could easily be distinguished from that of unsprayed trees. There was no drop of fruit at harvest time in Orchard A, and terminal growth was much greater than in previous years.

SELENIUM RESIDUE IN APPLES.—Samples of apples were taken in 1939 from an

Table 2.—Natural selenium content of apples and soil from a Wenatchee orchard.

SAMPLE NO.	DESCRIPTION	SELENIUM CONTENT p.p.m.
1	Soil, 0″ to 12″ deep	0.8
2	Soil, same as No. 1, except 12″ to 24″ deep	0.8
3	Soil, 0″ to 12″ deep	0.9
4	Soil, same as No. 3, except 12″ to 24″ deep	1.8
5	Ripe Jonathan apples grown on soil No. 1	less than 0.1
6	Ripe Jonathan apples grown on soil No. 3	less than 0.1

orchard near Wenatchee where *Selocide* had never been used. Samples of soil were taken under the trees from which the fruit samples were taken. These samples were carefully analyzed by the method used by Hoskins (1938). The selenium content of these samples is given in table 2.

These results show that soils near Wenatchee are naturally rather rich in selenium; nevertheless, Jonathan apples grown on these seleniferous soils do not take up selenium.

As previously mentioned, samples of ripe fruit were taken from the orchards sprayed with *Selocide*, as described in table 1. With the exception of the sample from Orchard A, half of each sample was washed in a commercial washer, as described in table 1. The selenium content of the washed fruit is compared with that of the unwashed fruit in table 1.

Unwashed Jonathan and Delicious apples from Orchard A showed only minute traces of selenium, either in the skin or in the flesh. This orchard was sprayed with *Selocide* before the fruit was set.

Samples 9, 10, 11, and 12 from Orchard B received three applications of *Selocide* during the growing season. Samples 13 and 14 were not sprayed with *Selocide*. Sample 9, sprayed three times with *Selocide* and not washed, contains no more selenium than sample 13, which was not sprayed with *Selocide*. Samples 10, 11, and 12 contain slightly less selenium than sample 13. There was a very slight deposit of selenium in the skin but no accumulation of selenium in the seed or core.

The samples from Orchards C, D, E, F, and G show only minute amounts of selenium either in the skin or flesh. This is true of samples sprayed early in the season (July 16) and late (August 20, 21) and is also true of both washed and unwashed fruit.

The quantities of selenium found in the sixteen samples of apples sprayed with *Selocide* are of about the same magnitude as found by Hoskins (1938) in citrus fruits and grapes sprayed with *Selocide*.

In no case was there any appreciable amount of selenium, either in the washed or unwashed fruit, even when sprayed three times. Only one application of *Selocide* per year would normally be required.

Three samples of wheat and one of rye were taken from fields in the Wenatchee Valley. The selenium content of these grains, which, of course, were not sprayed with *Selocide*, is shown in table 3.

Table 3.—Natural selenium content of Washington wheat and rye.

No.	Grain	Selenium Content p.p.m.
1	Wheat	0.40
2	Wheat	0.61
3	Wheat	0.49
4	Rye	0.30

The average selenium content of these grains was 0.45 parts per million.

The average selenium content of the unwashed apples sprayed with *Selocide* was 0.19 p. p. m.; that of the apples sprayed with *Selocide* and washed was also 0.19 p. p. m. The average selenium content of apples *not* sprayed with *Selocide* (Tables 1 and 2) was also 0.19 p. p. m.

From these results it would appear that the use of *Selocide* for the control of mites on apples offers no more hazard to public health than does its use on citrus and grapes, nor than the use of wheat and rye grown in seleniferous soils.

Samples of soil were taken from Orchard B, under the trees from which the apples sprayed three times with *Selocide* were taken and also under the trees from which the unsprayed apples were taken. The selenium content of these soils was determined by Hoskins (1938) method. The analyses are given in table 4. Comparison of soil samples 1 and 3 shows a very slight increase in the selenium content of

Table 4.—Selenium content of soil from Orchard B.

Sample No.	Depth	Treatment	Selenium p.p.m.
1	0″–12″	Not sprayed with *Selocide*	0.10
2	12″–24″	Not sprayed with *Selocide*	0.30
3	0″–12″	Sprayed 3 times with *Selocide*	0.34
4	12″–24″	Sprayed 3 times with *Selocide*	0.32

the first foot of soil following three applications of *Selocide* within a period of 70 days. This is the amount of *Selocide* that would normally be used in three successive years. There was no increase in the selenium content of the second foot of

soil. The lead and arsenic content of soil from Orchard B was 550 p.p.m. of lead and 130 p.p.m. of arsenic in the first foot and 68 p.p.m. lead and 100 p.p.m. arsenic in the second foot of depth.

COMPATIBILITY OF OTHER SPRAY MATERIALS.—The formula recommended for using *Selocide* on apples is:

1. Water	100	gals.
2. *Spredite* (Leffingwell potassium caseinate)	0.167	lb.
3. Medium Summer Oil (90 per cent or more unsulfonatable residue)	0.33	gal.
4. *Selocide Concentrate*	1	pt.

While the spray tank is filling with water, the *Spredite* is mixed with a little water, stirred until free from lumps and added to the water in the spray tank, with pump running. The medium oil is added and agitated until the spray tank is full. Finally the *Selocide Concentrate* is added and mixed thoroughly. It is necessary that the constituents be added in the order given.

To get the best results in applying *Selocide*, the foliage, fruit, limbs, and trunk should be thoroughly sprayed. It is necessary to hit the mites with the spray in order to kill them.

Selocide is not compatible with lead arsenate and cannot be mixed with lead arsenate sprays nor applied directly over a lead cover. However, lead arsenate sprays can be applied about a week after *Selocide* sprays. *Selocide* mixed with lead arsenate forms a black precipitate of lead sulfide and the solution contains soluble arsenate. The black precipitate will stain fruit and foliage and the soluble arsenate may cause some burn.

Spray tanks and lines which have been used with lead arsenate should be thoroughly cleaned before using them for *Selocide*. This can be done by allowing a solution of 1 pint of *Selocide* to 100 gallons of water to stand in the spray tank and pipe lines over night and then flushing with water until clear. If *Selocide* spray is then run through the lines it should not turn black.

Where it is desired to use lead arsenate throughout the season, *Selocide* can be applied before the calyx spray, as in the case of Orchard A, Table 1.

Selocide can be used with cryolite, either by mixing the two in the spray tank or by spraying over cryolite cover sprays. The following formula has given high kills of mites and eggs as well as satisfactory coverage against codling moth.

1. Water	100	gals.
2. *Spredite* (Leffingwell potassium caseinate)	0.167	lb.
3. Medium Summer Oil (90 per cent or more unsulfonatable residue)	0.33–0.5	gal.
4. Cryolite	3	lbs.
5. *Selocide*	1	pt.

While the tank is filling, the *Spredite*, oil, and cryolite are mixed thoroughly with water in a bucket and added to the water in the tank with the pump running. When the tank is full, the *Selocide* is added, mixed thoroughly, and the spray is applied. It is essential that *Selocide* be added last. Where ovicidal action against codling moth is desired, 0.5 gallon of oil is used instead of 0.33 gallon.

Selocide has been successfully used over lead cover sprays, where at least one cryolite cover spray has been applied over the lead cover sprays, before the *Selocide* spray is applied. Where growers use a split lead arsenate-cryolite spray program, *Selocide* can be used to advantage in the second or third cryolite spray.

In one experiment on Delicious trees the first cover spray was cryolite with 0.5 per cent oil; this was followed 2 days later with a *Selocide* spray containing 0.33 per cent oil. The fruit, which was about one half inch in diameter, dropped. This was due to the use of an excessive amount of oil on the young fruit. There was no damage to foliage.

Because of the oil content, *Selocide* spray should not be applied within one month of lime-sulfur dormant spray.

Selocide is compatible with nicotine and pyrethrum.

SUMMARY.—*Selocide* affords an efficient control for Pacific mite and European red mite and their eggs on apples. When properly used it causes no injury to fruit or trees.

Soils of the Wenatchee-Okanogan Valley are high in natural selenium content, but apples do not take up selenium from the soil.

Apples from an orchard sprayed with *Selocide* equivalent to three years' spray-schedule contained no more selenium than did apples from orchards which had never been sprayed with *Selocide*.

Comparisons of washed and unwashed

apples from orchards sprayed with *Selocide* indicate that washing to remove selenium residue is not necessary.

The amount of selenium added to the soil by one application of *Selocide* each year is negligible.

Apples contain about the same amount of selenium as do California citrus fruits and grapes. This is true of fruit sprayed with *Selocide* and fruit not so sprayed.

Selocide is compatible with cryolite, pyrethrum and nicotine. It is not compatible with lead arsenate but can be used in a lead arsenate spray program under certain conditions.—1-22-41.

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SCIENTIFIC NOTES

Removal of *Gasterophilus* Eggs from Horse Hair

Eggs of the horse bots *Gasterophilus nasalis* (L.) and *G. intestinalis* Deg. are cemented to the hairs of their host by the fly. The failure of these eggs to detach from the hair during processing for commercial use is sometimes a source of considerable concern. Tests were therefore conducted to devise a method for the removal of the eggs without injury to the hair.

The technic involved immersion of the hair, with attached eggs, into various potential egg or egg-cement solvents. In instances where egg removal was effected, subsequent tests of the tensile strength of the hair were made and the results were compared with those of similar tests on normal untreated hair. Tensile strength was selected as an index in determining injury, since deviation of this factor from the normal seemed to reflect other damages caused by treatment.

Tests for egg removal were conducted with many reagents, but since most of those tried were ineffective, only a few are worthy of mention. Boiling hydrochloric, sulfuric, and nitric acids at strengths ranging from 1 to 20 per cent removed the eggs but reduced the tensile strength of the hair, and in most instances impaired elasticity and refractiveness, and altered pigmentation. One per cent hydrochloric acid was the most promising of the acids tried, but hair immersed in this solution for 1 hour usually showed a tensile strength at least 10 per cent less than that of untreated hair. Five per cent solutions of sodium hydroxide or potassium hydroxide removed the eggs but practically destroyed the hair.

It was found that the cement which attaches the egg to the hair could be effectively hydrolyzed by immersion for 6 to 7 hours in a 0.5 per cent aqueous solution of 1–100 commercial trypsin at a pH of 7.2 to 8.0 and at a temperature of 38° C. A few eggs usually remained on the hair after treatment, but these were loosened and, with the exception of an occasional fragment, could be removed by spraying with a strong stream of water.

Trypsin solutions of less than one-half per cent were effective, but a longer time was required for egg removal, a 0.25 per cent solution requiring 24 to 30 hours. Trypsin solutions of more than one-half per cent did not appreciably decrease detachment time. Decrease in temperature or pH prolonged the process.

A given quantity of trypsin solution gradually loses its effectiveness after repeated use, an important factor if the process is ever to be employed commercially. The results of tests to determine this decrease in efficiency are shown in table 1. A one-half per cent solution was used, and all tests were conducted at a pH of 7.4 and at a temperature of 38° C. The solution was stored at 5.6° C. during the intervals between trials.

Table 1.—Time required in removing *Gasterophilus* eggs from horse hair for each treatment in the same trypsin solution.

SOLUTION USED, CC.	EGGS TREATED (ESTIMATED)	DATE, 1939	TIME REQUIRED; HOURS
100*	3,000	Apr. 17	6.0
95	3,000	18	6.5
87	2,000	19	7.0
80	2,000	20	8.0
70	1,000	21	15.0
65	500	24	40.0
58	500	26	74.0

* Initial quantity. The decrease after each test was due principally to loss by removal with wet hair.

A 0.5 per cent trypsin solution can be made for about 40 cents per gallon, even when the trypsin powder is purchased in small quantites.

A non-inactivating bacteriostatic substance must be added to the solution to prevent reduction of hydrolyzing properties by bacterial growth during use. The addition of about 1 gram of thymol per 100 cc. of solution was found to be satisfactory for this purpose.

Normal untreated horse hair selected to break at 50 grams or above showed a mean breaking-strength range of 77 to 78 grams per hair. The average breaking strength of such hair treated for egg removal

with trypsin showed no appreciable deviation from this mean. Other natural qualities of the hair were apparently not affected.

It is believed that the method described can be adapted for the removal of *Gasterophilus* eggs from detached commercial horse hair. It is not known, however, whether the method would be adaptable for the removal of eggs from hair remaining on the hide.

The utilization of this principle for the removal of louse eggs from other kinds of hair, such as valuable furs, has not been attempted.—7-3-40.

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Egg Parasites of the Harlequin Bug in North Carolina[1]

During the middle of September, 1939, the writer observed small Hymenopterous parasites ovipositing in eggs of the harlequin bug, *Murgantia histrionica* Hahn. It was discovered that two parasitic species were involved, *Ooencyrtus johnsoni* How. and *Trissolcus murgantiae* Ashm.[2]

White & Brannon (1933) state that three parasites are known that develop in the eggs of the harlequin bug. In addition to the aforementioned species these authors list *Trissolcus podisi* Morgan. They further state that, in so far as has been observed, none of these parasites has ever "become abundant enough throughout the infested territory to serve as a natural means of control." The same authors remarked that the harlequin bug is remarkably free of parasites or predators. Morgan (1897) stated that in 1896 *T. murgantiae* was found parasitizing harlequin bug eggs in many parts of Louisiana and in Mississippi. Over 60 per cent of field collected eggs were parasitized. Attempts were made to establish this species in Kentucky and Mississippi. However, Paddock (1918) stated that these attempts to establish the parasite in other states were "apparently without avail." Walker & Anderson (1933) reported that "*Ooencyrtus johnsoni* (How.) was found to be parasitizing from 35 to 55 per cent of all harlequin bug eggs collected during August and September" of the outbreak year of 1932.

The present data are presented as local evidence of the effectiveness of these two egg parasites in partially controlling the harlequin bug. It is quite possible that the usefulness of these insects generally has been overlooked. Only extensive field collections and the results obtained would have convinced the writer that they were really serving a good purpose in this case. The presence of these two species in North Carolina represents a new record. The writer is of the opinion that similar collections in other parts of North Carolina and in other states might result in the recognition of these species as important natural control agencies of the bug.

Since these collections were made near the end of the growing season, probably a higher percentage of parasitization existed than at any other period of the year. The eggs were collected from two locations, both in Raleigh, North Carolina. Each egg batch of the host insect was taken from the host plant and placed in a separate vial. This prevented any possible oviposition in unparasitized eggs by parasites which emerged early. The embryonic developmental period of the harlequin bug is much shorter than the total developmental period of the parasites; consequently no parasites emerged early enough to oviposit in eggs of the same batch before emergence of the harlequin bug nymphs took place. All eggs which failed to produce any insects were dissected, and in most cases it was possible to ascertain the sex as well as the species of parasite inside. The vast majority of such eggs contained *Trissolcus murgantiae*. Table 1 shows that 784 harlequin bug eggs produced 192, or 25 per cent, harlequin bug nymphs;

Table 1.—Field parasitization of harlequin bug eggs by *Trissolcus murgantiae* and *Ooencyrtus johnsoni* at two localizations in Raleigh, North Carolina.
(September 25 through October 6, 1939)

LOCALITY	NO. OF HOST EGGS	PER CENT PRODUCING BUGS	PER CENT PARASITIZED		
			O. johnsoni	*T. murgantiae*	Total
Methodist Orphanage Farm	319	15	37	48	85
N. C. Agr. Expt. Sta.	465	31	26	43	69
Total	784	25	30	45	75

238, or 30 per cent, *Ooencyrtus johnsoni;* and 354, or 45 per cent, *T. murgantiae*. This represents a total parasitization of 75 per cent for the two localities. The parasitization in the very heavily infested crop at the Methodist Orphanage farm was 37 per cent for *O. johnsoni* and 48 per cent for *T. murgantiae*—a total of 85 per cent. The same for the mildly infested and rotenone-controlled field was 26 per cent and 43 per cent respectively—a total of 69 per cent. These data undoubtedly constitute a record of economic interest, especially in so far as they reveal that the parasites may be effective before infestation has reached alarming proportions. The percentage of parasitization by *T. murgantiae* was greater than by *O. johnsoni* in both localities.

It is worth noting that all the individuals of *Trissolcus murgantiae* emerged from the anterior poles of the eggs. Two individuals that failed to emerge had developed with their heads turned toward the posterior poles. On the other hand, *Ooencyrtus johnsoni* emerged from the host egg at any point on the chorion. Only one individual of *T. murgantiae* developed to maturity in a host egg. The average number of *O. johnsoni* maturing in a host egg was 1.5, and some dissected eggs revealed 3 apparently normal adults.

In *Trissolcus murgantiae* females predominated, 84 to 16, but in *Ooencyrtus johnsoni* the ratio was 67 to 33. In addition, the distribution of the sexes was much more uniform in *T. murgantiae*. Only 2 batches of 12 eggs produced more than 2 males of this species. In many cases a majority of males and in at least one case all males of *O. johnsoni* were produced from certain batches of host eggs. The higher sex ratio, the more uniform occurrence of the sexes, and the higher percentage of parasitization indicate that *T. murgantiae* was the more valuable parasite in the cases concerned, though it does not exhibit multiple parasitization of the harlequin bug eggs.

In general, the life cycle of *Trissolcus murgantiae* is completed under favorable conditions in 10 to 14

[1] This paper is a result of work carried on by the writer when he was Research Fellow in Entomology for the N. C. Agri. Expt. Station.

[2] These species (Chalcidoidea and Proctotrypoidea respectively) were identified by Mr. S. C. Schell and the U. S. National Museum.

days. The cycle for *Oecneyrtus johnsoni* is somewhat longer. These data are taken from Morgan (1897), Walker & Anderson (1933) and the writer's observations.—12-9-40.

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Septis[1] Larvae Attacking Wheat and Wild Rice

Injury to wheat caused by *Septis finitima* Gn. was first observed by the writer during 1927. Since then such injury has been observed repeatedly. Small holes eaten in the kernels of wheat resembling injury caused by granary pests are characteristic of the work done by the small larvae to the growing wheat. Larger larvae of *S. finitima* consume part or all of the wheat kernels in the head, depending upon size of the larvae and other circumstances. The wheat is eaten while the kernels are soft and also after the kernels are mature.

Larvae have been taken on sedge, timothy, and from an ear of corn at Orono, and from wheat at Presque Isle, Maine.

Moths of *Septis finitima* are on wing from the second week in June until the latter part of July. They have been taken at Presque Isle, Orono, Unity, and on Mount Desert Island.

Rearing data and flight records indicate that there is a single generation in Maine. Partially grown larvae of several sizes are to be found at the time of year when hibernation occurs and it appears likely that none have reached the pupal or adult stage by the time winter arrives.

In cages maintained outdoors at Orono and Presque Isle, larvae of *S. finitima* fed on the mature kernels of wheat until cold weather and then went into hibernation beneath the wheat straw with which the cages were filled. Foliage of various plants offered to the caged larvae was not taken during the fall months nor after the hibernation period was broken during the following spring. The larvae fed on wheat kernels left in the cages and on fresh wheat offered to them later. The larvae completed their growth and were in the pupal stage by the first of June.

That *Septis finitima* is of considerable economic importance is indicated by complaints from growers regarding wheat consumed as well as the injury done to wheat intended for seed. It is probable that this species feeds even more widely on timothy than on wheat. Injury to timothy is also largely confined to the heads which in some cases are destroyed by feeding larvae.

[1] Lepidoptera-Phalaenidae.

Larvae of the genus *Septis* resembling *Septis finitima* in form and as to color pattern have been taken by the writer and others from wild rice growing in shallow water along the margins of streams in Maine. The habits of these larvae differ from those of *S. finitima* in that those of *S. finitima* hide in the soil or near the surface of the soil when not feeding while those of *Septis sp.* remain constantly on the rice plants until freezing weather occurs. Cells are made by the larvae consisting of silk and rice spikelets and leaves during the late summer and fall. Within this cell above the water the larvae remain when not feeding.

During the month of November the wild rice breaks off or is blown down and falls to the surface of the water. The larvae of *Septis* sp. leave the wild rice, at least in part, and walk or swim to the shore where they go into hibernation in the soil.

Larvae of *Septis* sp. destroy wild rice to such an extent that often there is not enough left to reseed the rice beds. Consequently wild ducks which have used wild rice for food and shelter have practically abandoned breeding grounds in streams and lakes in which they were once abundant.—1-14-41.

JOHN H. HAWKINS, *Maine Agricultural Experiment Station, Orono.*

Psocids Infest Chinchillas in Utah

Chinchilla breeding stock and their young at Smithfield, Utah, have been scratching and biting themselves recently, which often causes serious loss of hair. On one animal, all hair has been chewed from a portion of the tail. Other animals have pulled and scratched much hair from sides, flanks, and

FIG. 1.—Chinchillas showing patchy hair condition.

even from the top of the back, making the fur covering very "patchy." The value of any such furs would, of course, be greatly reduced. This condition was first called to the attention of the writers by Archie D. Egbert, D.V.M.

Examination of the nests revealed the presence of numerous small wingless psocids, one flea, two pseudoscorpions, a few dermestid larvae and one hemipterous nymph. The tiny psocids are extremely difficult to locate by visual examination among the dense hair of the Chinchillas.

It appears to the writers that this condition is largely, if not entirely, owing to psocid annoyance. The writers have been informed that similar hair

pulling occurs in several other portions of the United States.

The psocids collected from nests at Smithfield were identified by Dr. A. B. Gurney of the U. S. Bureau of Entomology and Plant Quarantine as *Liposcelis* sp. of the family Trogiidae. Members of this genus are known to live in birds' nests and other unusual places. It is possible that this species may have been introduced into this country when Chinchillas were brought in.—9-26-40.

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Dust Mixtures of a Phenol Salt for Control of Mites*

The dicyclohexylamine salt of 2-4-dinitro-6-cyclohexylphenol possesses certain physical and chemical properties which are a definite advantage, in insecticide mixtures, as compared with the parent phenol and certain of its organic and inorganic salts. The dicyclohexylamine salt is an orange-colored crystalline compound which has a faint typical nitro odor. It melts at a temperature of about 197°C. and decomposes at 204°C. The water solubility is comparatively low, being 0.0037 grams per 100 grams of the solvent at 20°C. It is appreciably soluble in certain organic solvents such as acetone, ethyl alcohol, and benzene. The vapor pressure of the dicyclohexylamine salt is considerably less than that of the parent phenol. This fact has been demonstrated by comparative tests, under controlled conditions, of their rates of sublimation from glass surfaces.

Many dust mixtures containing the salt have been prepared by solvent methods of mixing. Of pertinent interest is a mixture in which the dicyclohexylamine salt is prepared chemically in, on, and throughout an inert volcanic ash known as *Frianite*, at the rate of 1.7 per cent. This amount of the salt is chemically equivalent to the quantity of the parent phenol employed commercially in *DN Dust*, which is a dispersion of 1.0 per cent of 2-4-dinitro-6-cyclohexylphenol on *Frianite*.

Toxicological studies with the citrus red mite, *Paratetranchyus citri* (McG.), have shown that the dicyclohexylamine salt is nearly equal in toxicity to the parent phenol, when compared on the basis of equivalent weights of 2-4-dinitro-6-cyclohexylphenol. The speed of toxic action of the dicyclohexylamine salt, to the mites, appears to be a little slower than that of the parent phenol. However, because of its low vapor pressure and consequent more prolonged residual action, the salt is more effective over a longer period of time, under definite temperature conditions, than is the parent phenol.

Boyce *et al.* (1939) have pointed out that high temperature (95°F. and above) is a dominant factor in relation to the injury which occasionally occurs when a dust mixture containing 1 per cent 2-4-dinitro-6-cyclohexylphenol is applied to citrus. Recent investigations have shown that the cause of the rapid loss of this phenol, under high temperature conditions, has been primarily sublimation. Dust mixtures of the solvent mix type are exceedingly fine dispersions, and the surface area of the active chemical particles is tremendously large. Thus, the loss of the phenol by sublimation is increased sufficiently to be of highly significant importance. As the dicyclohexylamine salt has a vapor pressure lower than that of the parent phenol, it is more difficult to obtain a high concentration of its gaseous phase on a plant surface. The greater safety of dust mixtures which contain the dicyclohexylamine salt, compared with DN dust, has been demonstrated on citrus and other subtropical plants, deciduous fruits, and certain truck and field crops.

Dust mixtures containing the dicyclohexylamine salt of 2-4-dinitro-6-cyclohexylphenol have been found to be very toxic to several species of mites, including the citrus red mite, the common red spider, *Tetranychus telarius* (L.), the six-spotted mite, *T. sexmaculatus* Riley, the Pacific mite, *T. pacificus* (McG.), the clover mite, *Bryobia praetiosa* Koch, and the European red mite, *Paratetranychus pilosus* (C. & F.). The results of large-scale field tests have shown that a mixture which contains about 1.7 per cent of the amine salt is just as effective in the control of these tetranychid mites as *DN Dust* which contains 1.0 per cent of the parent phenol. The added safety, under high temperature conditions, with the new dust, makes it possible to control mites on many plants that will not readily tolerate *DN Dust*.

Dust mixtures that contain the amine salt have been found to be very toxic to the citrus thrips, *Scirtothrips citri* (Moulton), the greenhouse thrips, *Heliothrips haemorrhoidalis* (Bouché), and the bean thrips, *Hercothrips fasciatus* (Perg.). The amine salt in dust mixtures is toxic to the crawlers of the California red scale, *Aonidiella aurantii* (Mask.). Plant surfaces dusted are protected from the settling of the crawlers for a longer period than with *DN Dust*. This evidence further demonstrates the greater residual action of the amine salt. Tests have been conducted in the field with a dust containing 1.7 per cent of the phenate on black scale, *Saissetia oleae* (Bern.), and the resultant effectiveness was of a measurable degree. As in the case of *DN Dust*, the mixture killed the young of the scale insect for a period of about two weeks after they had settled on the citrus leaves. Laboratory tests on black scale have also shown the salt to be toxic when applied as a dust or dispersed in water as a spray. Petroleum oil can be used as a sticker with these water dispersions, and the inverted mixtures or inside dispersions which are formed can be used with safety on citrus.

Boyce & Prendergast (1936) pointed out that the addition of petroleum oil to dust mixtures containing 2-4-dinitro-6-cyclohexylphenol greatly improved the adhesive properties of the dusts. Because of injury to citrus (Boyce *et al.* 1939), it became necessary to discontinue the use of oil. The dicyclohexylamine salt of 2-4-dinitro-6-cyclohexylphenol is only sparingly soluble in petroleum oil as compared with the parent phenol; consequently, the salt can be employed with petroleum oil in dust mixtures without the same injury hazard. Because of the improved depositing and adhesive properties of dust mixtures containing oil, it has become possible to control the citrus red mite on lemons and oranges with decreased dosages of dust per tree, and also to control the mites on certain deciduous fruits and other crops.

Dust mixtures which contain the dicyclohexylamine salt of 2-4-dinitro-6-cyclohexylphenol have

* The authors wish to acknowledge the valuable assistance and suggestions rendered by Dr. A. M. Boyce of the Citrus Experiment Station, under whose immediate direction this investigation has been expedited. The development has been made possible through a grant from the Dow Chemical Company to the University of California. Many members of both organizations aided in this project.

proved to be of definite value to agriculture in the control of mites and certain species of thrips. Two new dust mixtures which contain about 1.7 per cent of the salt have been made available commercially and registered in the State of California under the trade names *DN Dust D-4* and *DN Dust D-8*.—12-26-40.

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Walnut Husk Fly Control Studies

The walnut husk fly, *Rhagoletis completa* Cress., is an important pest of English or Persian walnuts in a limited area in southern California. Several thousand acres of walnuts are infested at the present time and the insect is spreading to other areas. Cryolite is universally used for control; however, the results obtained during recent years have not been entirely satisfactory. During the past few years various materials have been used in control studies, in either the laboratory or the field, or in both. Since natural cryolite containing 93 per cent sodium fluoaluminate, approximately 95 per cent of which has a particle size of 5 microns or less, has been the most satisfactory material for control, the effectiveness of other materials used has been compared with this particular cryolite. Unless otherwise indicated, injury to walnuts has not been apparent under the conditions of the tests. Following are comments on the results obtained in the tests of various materials, which in certain instances were very limited.

Natural cryolite plus sugar.—In the laboratory the inclusion of sucrose in both sprays and dusts of natural cryolite resulted in greatly improved effectiveness. However, in extensive field trials with both sprays and dusts the inclusion of sucrose at relatively high dosages has not afforded measurably greater effectiveness.

Synthetic cryolite.—A relatively new product containing approximately 83 per cent sodium fluoaluminate, of a particle size ranging from 1 to 3 microns, has received fairly extensive consideration. For reasons not understood, the results obtained with this material have been consistently inferior to those from the natural cryolite when compared at equivalent dosages of sodium fluoaluminate in both spray and dust mixtures. Analyses of deposits showed that approximately equivalent quantities of the chemical were deposited in the sprays, although the deposits from dust mixtures were appreciably less with the synthetic cryolite than with the natural cryolite.

Barium fluosilicate.—In both laboratory and field tests the results obtained with this material have been approximately equal to those with the natural cryolite, when compared at equal dosages.

Basic zinc arsenate.—In fairly extensive field trials this material, when used at equal dosages in spray and dust mixtures, was slightly less effective in control than natural cryolite. Slight foliage injury occurred occasionally; however, it was negligible in importance.

Basic lead arsenate.—Extensive field trials have shown that this material is greatly inferior to natural cryolite; in fact, basic lead arsenate is of little value in the control of this insect.

Basic copper arsenate.—Under laboratory conditions, the indications are that this material, at equal dosages, is approximately as effective as natural cryolite. However, when sucrose was incorporated with basic copper arsenate, it was decidedly more effective than natural cryolite plus sucrose. Under field conditions, during two seasons, spray mixtures of basic copper arsenate at 4 pounds plus sucrose at 8 pounds per 100 gallons have afforded results in control superior to natural cryolite at the same dosage. This relatively new arsenical shows sufficient promise in control of the walnut husk fly to warrant fairly extensive investigation. Slight to moderate foliage injury has occurred on several occasions.

Tartar emetic.—Under laboratory conditions tartar emetic plus sucrose, applied as a spray, was very much more effective than natural cryolite. Tartar emetic without sugar was nearly valueless. In an attempt to find a substitute for highly refined sucrose in tartar emetic sprays, the following materials were compared: highly refined cane sugar, brown sugar, sorghum, honey, levulose, dextrose, lactose, glycerol, casein, glycine, and saccharin. Under the conditions of these tests, tartar emetic was found to be most effective when used with sucrose, levulose, or dextrose, or materials containing these sugars. Limited laboratory tests for the determination of the optimum sucrose content of a spray mixture with 4 pounds of tartar emetic showed no significant differences in effectiveness between 2, 4, and 8 pounds of sucrose per 100 gallons.

Extensive field trials with sprays of tartar emetic at 4 pounds plus sucrose at 8 pounds per 100 gallons, with thorough application, have scarcely afforded any measurable degree of control. This is a distinct reversal of the results obtained in the laboratory, the reasons for which are not understood. When tartar emetic plus sucrose was incorporated with natural cryolite in both spray and dust mixtures, the degree of control was not measurably increased over the tests in which cryolite was used alone.

Cuprous cyanide.—When this material was compared with natural cryolite, at equal dosages, the results in control were approximately equal. Slight injury to walnut foliage occurred; however, this was of negligible importance.

Phenothiazine (1938 product).—Under laboratory conditions, used as spray and dust, this material was inferior to natural cryolite plus sucrose. Limited tests with phenothiazine indicated that the material was more effective after it had weathered for seven days than when it had not weathered. In field tests the results in control obtained from sprays and dusts were very greatly inferior to those obtained from natural cryolite at equal dosages.

Xanthone (*Genicide*).—Under field conditions, where this material was used as spray and dust no measurable degree of control was obtained in limited

trials. Moderate to severe foliage injury occurred in all plots.

Derris or Cubé.—Dust mixtures, of either derris or cubé, containing 1 per cent rotenone were very effective in causing mortality under laboratory conditions. While an appreciable mortality occurred under field conditions, the results in control obtained from three treatments with a 1 per cent rotenone-bearing dust mixture, applied at fifteen day intervals, were unsatisfactory. The incorporation of derris or cubé in the conventional 35 per cent natural cryolite dust mixture in proportions to give 1 per cent rotenone, did not measurably improve the effectiveness of the cryolite in control of the fly. —12-26-40.

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The Field Roach *Blattella vaga*

The field roach, *Blattella vaga* Hebard, is one of the least known of the introduced roaches in the United States. It was first recognized by Dr. Ball who collected it at Phoenix. The species was described from Ball's specimens in 1935 by Morgan Hebard (Hebard 1935), who considers it to have been introduced because its nearest relative is found in India.

One reason that this roach is not better known is that it has been confused with the common German cockroach *Blattella germanica*. It is very similar to that species in general appearance. It can be most easily distinguished by the blackish brown area on the face from mouth parts to between the eyes. This species is slightly smaller and more olivaceous in coloration than is the German roach.

Blettella vaga is very common in most of the irrigated regions of the Lower Sonoran Zone in southern Arizona. Although it was first recognized as distinct in 1933, the writer has specimens taken at light in Phoenix in 1928 where it is very well established. The roach was first found in the Santa Cruz Valley at Tucson during 1939 and is apparently to be found all along this valley down into the Salt River Valley. The distribution also includes the Gila Valley and the Colorado Valley. It is very common at Yuma, at Somerton, Arizona, and at Bard, California, and was collected by Dr. R. H. Beamer north along the Colorado River at Blythe, California. Dr. L. P. Wehrle has evidence which indicates that it may be found as far west as San Diego, California.

Typically, this roach is an inhabitant of irrigated fields and yards but is found in lesser numbers out on the dry desert. It is easily found under stones, plant debris, clumps of dirt and other objects. In the early spring months up until about the end of April all stages may easily be found near the surface of the ground. Later in the season because of the heat they are harder to find. The species appears to be associated to a considerable extent with decomposing vegetation and probably feeds largely on this material. The writer found this species in greatest abundance about decaying dates on the ground in a grove at Yuma. In the laboratory this roach will do considerable damage to tender plant parts, such as newly emerged seedlings. On the other hand, it shows some tendency to eat plant lice. It is probable that this roach is not very important in the field.

During the dryer seasons of the year the roach may come into houses in great numbers. This movement, for the purpose of obtaining moisture, is usually temporary. It does, however, remain in houses and breed there to some extent, and is carried from place to place in baggage. In the house its feeding habits are quite similar to those of the German roach. This roach is quite conspicuous in the house because it does not seem very sensitive to artificial light, and will wander around in the evening where it can be seen easily. It is also quite common around street lights and show windows. The field roach appears to be less wary than the German roach and is much more easily caught.

The practice of piling up cut grass and other mulch around plants against foundations is apt to increase greatly the number of roaches entering the house. Several house infestations have been eliminated by the simple method of removing decomposing plant material from around the foundation.

SUMMARY.—The field roach, *Blattella vaga* Hebard, is quite common in the Lower Sonoran Zone in Arizona. It occasionally does damage to plants or is a nuisance in houses. This roach is very closely related to the domiciliary German roach and possibly represents an intermediate stage in the acquisition of domiciliary habits.—1-2-41.

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Response of *Anabrus simplex* to Temperature

During the months of June and July, 1939, while working in northern Nevada, I collected fragmentary data on the temperature limitations of the Mormon cricket, *Anabrus simplex*, Haldeman, which may be recorded. While investigating a large, migrating band eight miles south of Mountain City, Elko County, I took daily temperature readings over a period of one week with a pre-checked standard laboratory Centigrade thermometer. Temperatures during this time remained consistently constant, and the following averages were obtained: (1) at 7:30 A.M., air temperature 26°C., ground temperature 39°C.; (2) at 9:30 A.M., air temperature 29°C., ground temperature 49°C.

I found the greatest number of crickets migrating at 7:30 A.M., thus indicating that temperatures were at an optimum during that hour. By 9:30 A.M. comparatively few were on the march, and by 10:00 A.M., they were feeding and resting in large numbers on and under the surrounding sagebrush.

As regards this upper limit of temperature endurance in the Mormon cricket, Cowan states that " . . . migrations . . . cease entirely when the temperature at the surface of the soil reaches approximately 100°F." This checks with the author's results, and any small difference, if significant, is probably a function of the humidity, upon which readings were not taken.

While working in the Diamond A area in northern Elko County, I was fortunate in obtaining data on the cricket's lower limits of temperature tolerance. During the afternoon of June 16, cold winds swept across the region, and the air temperature two inches above the ground hovered between 6° and 9°C., yet crickets were found migrating southeasterly up the flats, into the face of the wind!

Late in the afternoon of the following day, I caught nine crickets, which was the sum total to be

found under rocks and debris during an intensive two-hour search. These were placed in a well-perforated can which was left in the open to chill them to environmental temperatures in order to determine body heat in relation to atmospheric heat. The method employed was to make an incision at the tip of the abdomen slightly smaller than the bulb of the thermometer so that the instrument, when inserted, would fit tightly, and minimize loss of body heat. The entire mercury content of the thermometer was thus placed within the body cavity, so I consider the readings accurate.

The small number of crickets utilized was partially offset by the fact that the thermometer was first inserted into two "control" crickets, in succession, in order to bring it to approximately average body temperature before taking readings from the remaining crickets. The controls do not appear in the table. Thus, while the number of animals utilized is insignificant from the standpoint of generalizations, yet the results are probably consistent. The crickets, when thoroughly chilled, were still capable of slowly moving about when released from the can prior to the experiment. Table 1 gives a graphic illustration of the results: 9-11-40. IRA LA RIVERO, *Reno, Nevada.*

Table 1.—Temperature reactions of Mormon cricket adults.

No.	Temperature, °C.			Sex
	Air	Body	Difference	
1	3.5	11.0	7.5	♀
2	3.0	9.0	6.0	♀
3	3.5	5.0	1.5	♀
4	2.5	6.0	3.5	♂
5	2.5	4.75	2.25	♀
6	3.25	5.0	1.75	♂
7	2.0	5.0	3.0	♂
Averages	2.89	6.53	3.64	

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Cowan, Frank T. 1929. Life History, Habits, and Control of the Mormon Cricket. U.S.D.A. Tech. Bul. **161.**

Observations on the Periodical Cicada

During a period of several years the writer has had opportunity to observe the periodical cicada, *Magicicada septendecim* (L.), in various parts of West Virginia. During this period he has been particularly interested in the distribution of the several broods which occur in the state and in the habits of the insects and the damage which they may do.

It has been generally conceded that the insect may inflict serious damage on fruit trees and other woody plants; records of the persistence of the damage seem not to have been numerous, although Marlatt (1907) has illustrated damage to pear twigs which still was recognizable after a period of seventeen years. That such injury often endures over a period of several years is the conclusion of the writer, numerous cases of old injury having been observed. Figure 1, from a photograph taken in 1940, shows damage done by an individual of Brood V, which occurred in the state in 1931. The figure also shows new egg slits, formed in 1940 by a cicada of Brood XIV, placed in a twig among the nine-year old slits.

Such observations give positive evidence that more than one brood may occur in one locality in numbers sufficient to do considerable damage. Such overlapping of the two broods, V and XIV, was noted in several widely separated counties in this state and it is known that such has also been the case in other states.

There is also evidence of the overlapping of other broods of the cicada in other parts of West Virginia but the instances noted are the only ones which give the positive evidence of the occurrence of the insect in injurious numbers. Overlapping of broods

FIG. 1.—Two views of an apple twig showing egg slits of broods V and XIV of the periodical cicada.

by scattered individuals is not at all uncommon; it is only considered unusual to find the heavy populations occupying the same areas.

These observations tend to raise the question as to why the cicada seems to remain in highly localized areas, so far as concentrated, heavy populations are concerned. Marlatt (1907) says "The local abundance of the cicada in well-defined districts is to be explained by the fact, already noted, that the winged insect is sluggish, and scatters but little from the point of emergence, which, with favoring circumstances, tends constantly to concentrate rather than to scatter the species." Our observations tend to confirm the fact of the failure of the insect to spread since the heavy populations are still to be found in the places where they were originally observed, often many years ago, and new foci of abundance seem not to have developed. Careful observation of several such heavily infested localities shows that the boundaries are well defined and that there seems to be little or no tendency of the insects to scatter beyond the limits. They also seem to indicate that population, with resultant damage, is heaviest near the outer edge of the infestation, indicating that the insects may tend to spread from the interior of the area toward the outer boundaries but not to go farther and, possibly, not to migrate so freely from the edges toward the center. It has been noted in several cases that the cicadas disappear completely in a distance of less than a mile from the heaviest populations.

The statement that cicadas are sluggish insects may convey a somewhat inaccurate impression of their actual activity. They fly readily and rather strongly when disturbed and, at times, of their own volition and may be seen to fly in all directions when they are numerous. The reason for their failure to disperse more widely has hardly been established, beyond the mere statement that they seem to tend to stay in one place.

It has occurred to the writer that a possible explanation may lie in the sound produced by the males. It seems entirely possible that the insects tend to fly toward the greatest volume of sound and that individuals which chance to fly away from the main brood are drawn back toward it by the sound, always of greatest volume where the individuals are concentrated. Whether this sound attracts both sexes, if it is actually attractive to either, is a matter for speculation. In any case, the theory that the sound tends to draw in stragglers furnishes an explanation of the observations of their distribution which seems to fit.—11-5-40.

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Attraction of *Rhagoletis pomonella* Adults to Protein Baits[1]

McPhail's (1939) report of the attractiveness of protein lures to the Central American fruit fly, *Anastrepha striata* Schiner, led to the following tests of decomposing protein baits as attractants for the apple fruit fly, *Rhagoletis pomonella* Walsh. The materials tested are listed in Table 1, the amounts indicated being dissolved or suspended in one liter of tap water. The traps used were made of glass, with closed tops and a single cone-shaped opening in the bottom. This construction eliminated the possibility of flies accidently falling into the trap, since they could only gain entrance by crawling upward through the funnel-like opening.

The traps were hung at various levels in apple trees of the variety Twenty Ounce in a heavily-infested orchard near Rhinebeck, N. Y., on July 10, 1940, several days after cage emergence had started. On July 23, new materials were substituted for some of the less promising baits. Examinations were made at three-day intervals until August 17, when all traps were removed. The records of all traps are summarized in Table 1.

The number of flies caught was considerably greater than had been anticipated, considering the failure of past attempts to attract this species with aromatic or sweetened baits. The tests were too limited to permit the drawing of conclusions other than that some of the protein lures were definitely attractive to the apple fruit fly. As compared with fly emergence in cages, the peak captures in traps occurred three days later than peak emergence. Females constituted 83.3 per cent of the total number of flies caught in traps as compared with 59.5 per cent of the number emerging in cages. This would seem to indicate a definite difference in the degree of response to the baits by the two sexes.—1-20-41.

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Table 1.—Number of apple fruit flies captured in protein-baited traps, July 10–Aug. 17, 1940.

Bait, Grams Used per Liter of Water	Number of Traps	Period of Operation	Total Flies Captured			Average Flies per Day per Trap		
			♀	♂	Total	♀	♂	Total
Powdered Egg Albumin 40 gms.	4	July 23–Aug. 17	372	74	446	3.720	0.740	4.550
Bacto-Peptone 10 gms.	4	July 23–Aug. 17	259	43	302	2.59	0.430	3.040
Dried Yeast Powder 40 gms. + Lye 40 gms.	4	July 10–Aug. 17	293	79	372	1.927	0.520	2.447
Glycocoll 2 gms.	4	July 10–July 23	33	3	36	1.225	0.098	1.323
	2	July 23–Aug. 17	92	7	99			
Bacto-Peptone 20 gms.	4	July 10–Aug. 17	154	40	194	1.013	0.263	1.276
Protease-Peptone 20 gms.	4	July 10–Aug. 6	114	21	135	0.943	0.163	1.106
	3	Aug. 6–Aug. 17	19	2	21			
Blood Albumin 40 gms. + Lye 40 gms.	4	July 10–Aug. 17	124	31	155	0.816	0.204	1.020
Casein 40 gms. + Lye 40 gms.	4	July 10–July 23	54	12	66	0.725	0.147	0.872
	2	July 23–Aug. 17	20	3	23			
Powdered Egg Albumin 40 gms. + Lye 40 gms.	4	July 10–Aug. 17	107	20	127	0.704	0.131	0.835
Blood Fibrin 40 gms. + Lye 40 gms.	4	July 10–July 23	45	7	52	0.667	0.088	0.755
	2	July 23–Aug. 17	23	2	25			
Fresh Egg White (4) + Lye 80 gms.	4	July 10–July 23	28	2	30	0.538	0.038	0.576
Whole-Milk Powder 40 gms. + Lye 40 gms.	4	July 10–July 23	15	8	23	0.288	0.154	0.442
Skim-Milk Powder 40 gms. + Lye 40 gms.	4	July 23–Aug. 17	32	4	36	0.320	0.040	0.360
Gelatin 40 gms. + Lye 40 gms.	4	July 10–July 23	10	2	12	0.192	0.038	0.230
Lye 40 gms.	2	July 23–Aug. 17	1	0	1	0.020	0.000	0.020
Water	6	July 10–Aug. 17	1	0	1	0.004	0.000	0.004
Cane Sugar 40 gms.	4	July 23–Aug. 17	0	0	0	0.000	0.000	0.000
Total			1796	360	2156			
Average						0.923	0.157	1.080

[1] Approved by the Director of the New York State Agricultural Experiment Station for publication as Journal Paper No. 423, January 6, 1941.

Insect Food of the Chipping Sparrow

The chipping sparrow, *Spizella passerina arizonae* Coues, is a common inhabitant of farms, gardens, orchards and range land throughout Utah. In the fall, flocks have been encountered on the breeding grounds of the sugarbeet leafhopper, feeding upon this serious agricultural pest. The following report deals only with recognizable insect remains found in the stomachs (gizzards) of 41 specimens collected throughout Utah during the season of 1940.

Thysanura 2, one a Machilidae. Collembola 23, in five stomachs. Orthoptera 15 in nine stomachs, including 9 adult and 5 nymphal grasshoppers, one of these being a Tetrigidae; one *Melanoplus mexi-*

canus (Sauss.); and one field cricket, *Gryllus assimilis* (Fabr.). Isoptera 3, *Reticulitermes*. Odonata 2, Zygoptera. Neuroptera 1, *Chrysopa*. Thysanoptera 2. Homoptera constituted the largest number of individuals, consisting of 1,543 recognizable specimens, of which 17 adults and 18 nymphs, *Eutettix tenellus* (Baker) in thirteen stomachs, 193 *Thamnotettix geminatus* Van D. in eight stomachs, and a few specimens of *Agallia* and *Aceratagallia;* 1 Membracidae, *Ceresa bubalus* (Fab.), 1 Fulgoridae, *Scolops;* 1, Coccidae; 1,223 aphids in twenty-three of the stomachs, of which at least 614 were *Macrosiphum pisi* (Kalt.) in thirteen stomachs, 10 *M. escalantii* Knlt., 4 *M. laevigatae* Essig, 134 *M. coweni* (Hunter), 3 *M. packi* Knlt., 11 *Capitophorus oestlundi* Knlt., 23 *Lachnus salignus* (Gm.), 5 *Clavigerus bicolor* (Oest.), 1 *C. smithiae* (Mon.), 2 *Periphyllus macrostachyae* (Essig), 1 *Cavariella capreae* (Fab.), 12 *Epamiebaphis atricornis* G.-P., 2 *Brevicoryne brassicae* (L.), 12 *Aphis bonnevillensis* Knlt., 4 *A. carbocolor* Gill., 2 *A. chrysothamni* Wils., 2 *A. gregalis* Knlt., 2 *A. minutissima* G.-P., 22 *A. medicaginis* Koch, 1 *A. rumicis* L. Hemiptera 371 including 258 adult and 8 nymphal, *Nysius ericae* (Sch.) in 19 stomachs, 2 *Geocoris decoratus* Uhl., 18 Miridae of which 5 were *Lygus hesperus* Knt. and 1 *L. elisus* Van D., 2 Pentatomidae, 1 Reduviidae and 1 Nabidae, *Nabis alternata* (Parsh.). Coleoptera 155, including 13 Chrysomelidae of which one was *Psylliodes punctulata* Melsh. and 2 *Systena taeniata* (Say); 1 Histeridae; 1 Melyridae, *Collops bipunctatus* Say; 1 Elateridae; 2 Buprestidae; 1 Coccinellidae, *Hippodamia convergens* Guerin; 2 Tenebrionidae; 2 Scarabaeidae, one an *Aphodius;* 1 Mylabridae, *Mylabris pisorum* (L.), and 12 Curculionidae including 4 adult and 2 larval alfalfa weevils; 1 Gyrinidae. Diptera 31, including 8 mosquitoes in six stomachs; Chironomidae 11 in one stomach; 1 *Pipunculus* larva (protruding from partly digested abdomen of a beet leafhopper); 3 Syrphidae, one each being *Chrysogaster bellula* Will., *Copestylum marginatum* Say and *Eupeodes volucris* O.S.; 2 Calliphoridae, *Calliphora;* 1 Chloropidae, *Chloropisca glabra* (Meig.). Trichoptera 2 in one stomach. Lepidoptera 35, of which 32 were larvae, 11 being those of the diamond back moth in three stomachs; 11 lepidopterous eggs also were found in two stomachs. Hymenoptera 87, of which 34 were ants in twelve stomachs, including *Pogonomyrmex occidentalis* (Cress.), several *Myrmica* sp., 2 wild bees, 5 Braconidae including one *Lysiphlebus* and three *Aphidius*. Four stomachs contained 7 Arachnida, three of which appeared to be "red spiders." In addition to insect and spider material were 365 recognizable seeds, largely of weeds, including seeds of *Chenopodium, Atriplex*, Russian-thistle, mustards, cheatgrass as well as of other weeds and grasses. No seeds of cultivated grains were found.—1-16-41.

G. F. KNOWLTON and F. C. HARMSTON. *Utah Agricultural Experiment Station, Logan.*

THE JUNE SYMPOSIUM AT DURHAM, NEW HAMPSHIRE

In accordance with vote of the Association at Philadelphia, a special two-day symposium will be held in the period between June 23 and June 27th in connection with the summer meeting of the American Association for the Advancement of Science, which will convene this year on the campus of the University of New Hampshire, at Durham. A number of national scientific societies, or sections of national societies, have already made arrangements to take part. This, of course, is in addition to the various sections of the A.A.A.S. itself.

The symposium to be held by our own Association promises to be noteworthy. The subject is "Experimental Procedures in Investigation of the Chemical Control of Insects." The committee on the symposium will sub-divide this subject into several phases, beginning with the rearing of insects, and proceeding with techniques in studies of stomach poisons, contact insecticides, ovicides, attractants, repellents, fumigants, wetting agents, and allied topics. Each topic will be assigned to an entomologist who has specialized in that particular field of research. It is expected that the assembled papers will be published in book form and thus will become available to entomologists for future use.

All meetings will take place on the campus of the University, where ample facilities will be available. The symposium will occupy the morning and afternoon sessions of the two days. Each evening the A.A.A.S. will sponsor a lecture by a nationally-known authority. Thursday evening, June 26, there will be a complimentary concert.

All meeting places and dormitories are within five minutes' walk of one another, and are adjacent to the railway station. Those who wish may have their meals at the University Commons, which is attractively furnished and is equipped to care for a large number of guests. At the Commons there are both dining-halls and cafeterias.

Housing facilities will be available at the University's modern dormitories, at the rate of one dollar per night per person. One of the large dormitories will be set aside for men with their families. Applications for rooms should be made to the University treasurer. In addition, there are many hotels within a short distance of the campus, some of which are situated on the seacoast, twenty minutes' drive over modern highways. A list of hotels, with locations and rates, will be available at an early date.

The University is sixty-two miles from Boston on the main line of the Boston & Maine railroad. Trunk line highways lead to Durham from the south, west, and north.

Various ranges of the White Mountains begin forty miles from Durham and extend north 125 miles. Good roads lead through the mountains. The highest summits are above timber line and present an interesting Arctic flora and fauna. A lake region of exceptional beauty lies between Durham and the mountains. Montreal and Quebec can be reached in one day by car. Nova Scotia, New Brunswick, and the Gaspé Peninsula offer attractive objectives.—1-18-41.

W. C. O'KANE

JOURNAL OF ECONOMIC ENTOMOLOGY
Official Organ American Association of Economic Entomologists
Vol. 34 February, 1941 No. 1

The 1941 Journal

OUR statistical friends who are wont to solve all problems, human and entomological, by the computation of least squares, significant differences at odds of 16 to one, plotting curves on semi-logarithmic scales and other devices calculated to mystify the uninitiated, who can follow such regimented reasoning only far enough to comprehend that there is a probable error somewhere, will readily understand the law of diminishing returns. Even working entomologists will admit the existence of such a law, having felt its effects and become convinced of the inexorability of its action.

In the progress of the JOURNAL, no less than in other fields of endeavor, the influence of the law can be recognized. In the earlier days of the JOURNAL annual progress might have been measured by a yardstick; today, that point on the curve of development has been reached where progress, if any, must be detected with the millimeter scale.

Progress may be manifested in several ways. The more obvious of these include the physical form and the quality of the content. Three volumes of the JOURNAL in its new format must have convinced the most skeptical that the last big improvement in physical form to be expected for a period of years was accomplished when the new format was adopted.

Improvement in the quality of the content will come gradually, imperceptibly almost, and will necessitate cooperation. The contributors must, and will, become more critical of their own work and more careful in its presentation; the publication committee must cooperate by constructive criticism and by suggestions concerning effective presentation of material.

Undoubtedly there are other ways in which the JOURNAL can be improved. If it is made more useful to the readers it will show progress. One way in which this may be done is by broadening its scope; by considering every change, no matter how trifling, which may tend to make it more useful to the readers. Some such changes may well be suggested by readers and contributors and are cordially invited. Some must come from those entrusted with the management of the JOURNAL. In this connection we wish to point out one type of contribution which might well make the JOURNAL more useful and interesting but which has been neglected to a degree. An excellent example of this is furnished by a note contributed by Miss Eugenia McDaniel and appended to this article. This is a simple report of tests which the author had occasion to make. It does not pretend to report research, as we commonly use the term; it is not exhaustive; but merely gives a concise statement of what was done and the results.

During the course of any year entomologists over the country certainly have occasion to make many similar tests; work which is usually without the scope of their more important organized research projects; work which is immediately necessary; work which is possible only when an infestation of an occasional insect chances to be convenient. And, above all, work which deserves to go on record and which will be most effective if presented promptly, simply and briefly.

The editor proposes to use such notes, as fillers, often to utilize space which might otherwise be wasted. Contributors will be well able to judge the suitability of items.

With the cordial cooperation which the experience of the past year assures the editor will be his so long as he merits it, and with no radical change in any phase of the publication policy, the editor hopes, with the invaluable assistance afforded by the members of the Publications Committee, that the JOURNAL may show progress measurable, if not with the yardstick, at least with the millimeter scale. L. M. P.

SPRAYING TO CONTROL *Rhyacionia buoliana*

Preliminary experimental work conducted during 1940 indicates that *Black Leaf 155* (14 per cent) will control the European pine shoot moth, *Rhyacionia buoliana*. The spray was applied with a power sprayer giving 600 pounds pressure at the nozzle. The dilution used was 3 pounds *Black Leaf 155* (14 per cent) to 100 gallons of water plus 1 quart of *Dendrol* dormant oil.

Under Michigan conditions, two applications are necessary. The first application should be made about June 30th and the second about July 8th or 10th.—1-11-41.

E. I. MCDANIEL, *Department of Entomology Michigan State College, East Lansing.*

THE SIXTEENTH ROCKY MOUNTAIN CONFERENCE

The 16th annual Rocky Mountain Conference of Entomologists was held August 18 to 23, 1940, at Cameron Pass Camp, Colorado. The camp is located in the heart of the Rockies, 77 miles west and north from Fort Collins, at an altitude of about 9500 feet. Members of families became a part of the group cared for at the comfortable yet isolated camp. Ninety-two persons representing 17 states and the District of Columbia were in attendance. Those directly interested in entomology were:

Allen, Merle W.
Anderson, Carl C.
Arbuthnot, K. E.
Beals, Edward P.
Beamer, Lucy
Beamer, R. H.
Brown, F. Martin
Connelly, Al
Decker, Clayton
Doering, Kathleen
Edelblute, Lyle
Fletcher, Robert K.
Gates, F. Herbert
Gillette, C. P.
Greenwalt, Margaret
Hall, David
Hayes, W. P.
Hixson, Ephraim
Hoerner, John L.
James, Maurice
Jones, C. R.
Kenaga, Eugene
Knight, Paul
Knowlton, G. F.
Kuitrel, Louis C.
Lapovsky, Louis J.
List, George M.
McCampbell, Sam C.
Maxwell, J. Myron
Mickel, Clarence
Milliron, H. E.
Muesebeck, C. F. W.
Newton, J. H.
Nye, Wm. P.
Painter, Reginald H.
Palmer, Miriam A.
Payne, Nellie M.
Portman, Roland
Potts, Bob
Potts, Jerry
Reeves, George I.
Robb, Theodore R.
Rohwer, S. A.
Rohwer, Mrs. S. A.
Sabrosky, Curtis W.
Scott, John W.
Severin, H. C.
Shockley, Wilfred
Stehr, Wm. C.
Sugarman, Jack
Wakeland, Claude

All programs were in the form of discussions. The topic "Insect Taxonomy, its Fundamental Principles, Methods, and Relations to other Branches of Biological Science" formed a principal theme.

Subdivisions of this topic were discussed as follows:

1. *The species problem:*—Clarence Mickel—Leader; Bob Potts, S. A. Rohwer, R. H. Painter, Miriam A. Palmer, M. T. James, C. W. Sabrosky, W. P. Hayes, R. H. Beamer, F. M. Brown, K. D. Arbuthnot, H. C. Severin, David Hall, C. F. W. Muesebeck and G. F. Knowlton.
   a. Taxonomy and natural populations.
   b. Should we recognize sub-species, sub-genera, etc.?
   c. What is a species?
   d. What is a genus?
   e. Relation of modern genetics to taxonomy.
   f. Taxonomy and biology.
   g. Taxonomy of immature insects.
2. *Codes and Nomenclature:*—C. F. W. Muesebeck—Leader; M. T. James, Clarence Mickel, S. A. Rohwer, F. M. Brown, R. H. Painter, C. W. Sabrosky, G. F. Knowlton.
   a. History of taxonomy.
   b. Stabilizing nomenclature.
   c. Do codes of nomenclature need revision and in what direction?
   d. Priority of names in categories below species.
3. *Methods:*—M. T. James—Leader; R. H. Beamer C. F. W. Muesebeck, W. P. Hayes, F. M. Brown, R. H. Painter.
   a. Important methods of mounting.
   b. Special methods of mounting (for special groups).
   c. Preserving in liquid.
   d. Preserving collections while in the field.
   e. Mounts for class room uses.
   f. Methods of doing taxonomic work and studying phylogeny.
   g. Standards for labelling.
4. *Relation of taxonomists to other workers:*—S. A. Rohwer—Leader; Claude Wakeland, C. F. W. Muesebeck, G. F. Knowlton, R. H. Painter, R. H. Beamer, C. W. Sabrosky, F. M. Brown.
   a. How can the taxonomists better serve the economic entomologists and other special workers?
   b. How can better support be gained for taxonomic research?
   c. Keys for the economic entomologist.
   d. Sources of material for taxonomic work.
   e. Groups of insects and problems requiring study.
   f. How may non-taxonomic workers aid the taxonomist?
   h. When does insect taxonomy become economic entomology?
5. *Training the taxonomist.*—George M. List—Leader; R. H. Painter, S. A. Rohwer, W. P. Hayes.
   a. How much taxonomy should be given the student receiving only a single course in economic entomology?
   b. Facilities for the study of types and of extensive collections by beginning workers.
   c. Under what conditions should graduate students be encouraged to describe new species?

Other topics presented during the week were:

The organization and work of the United States Bureau of Entomology and Plant Quarantine S. A. Rohwer

Some important insect problems in Oklahoma, Ephraim Hixson

Extension entomology in Oklahoma, M. J. Maxwell

The grasshopper and Mormon cricket control program in the Western states, Claude Wakeland

A review of the Utah research program, George F. Knowlton

Insect problems in South Dakota, H. C. Severin

Host and parasite relationship, Nellie M. Payne

Colorado insect problems, George M. List

The codling moth and peach mosaic problems in Western Colorado, J. H. Newton

A report of the principal insect problems of the year in Kansas, R. H. Painter

The entire day of August 21 was given to collecting, mountain climbing and general recreation, while the evenings were taken up largely by the showing of wild life and scenic pictures of general interest and to a social good time. The following resolutions of general interest were passed by the Conference:

Whereas, The opinions of the International Commission of Zoological Nomenclature are with great difficulty accessible to students and workers in taxonomic entomology, and there is a need and a demand for their publication;

Be it Resolved, That the Rocky Mountain Entomological Conference encourage the publication of the International Code of Zoological Nomenclature, together with all of the complete opinions rendered by the International Commission of Zoology Nomenclature.

AND WHEREAS, One of our members, Dr. RALPH VORIS, has passed away since our last annual Conference

THEREFORE, Be It Resolved, That the Secretary be instructed to convey to Mrs. Ralph Voris our sincerest regrets and deepest sympathy.

AND WHEREAS, Our Honorary Chairman, Dr. C. P. GILLETTE has been unable, on account of illness, to attend the meetings of the Comference for several years past, and has been able to be with us at this sixteenth Annual Conference.

THEREFORE, Be It Resolved, That we express our happiness and pleasure for his improved health and for his presence with us.

The officers for the 1940 meetings were R. H. PAINTER, *Chairman;* GEO. F. KNOWLTON, *Vice-chairman.* Those elected for 1941 were H. C. SEVERIN *Chairman;* CLAUDE WAKELAND, *Vice-chairman;* C. P. GILLETTE, *Honorary Chairman;* C. R. JONES, *Treasurer*, and GEO. M. LIST, *Secretary.*

GEORGE M. LIST, *Secretary*

BOOK REVIEW

Entomophagous Insects by Curtis P. Clausen. Pages i–x, 1–688, 257 text figures, McGraw-Hill Book Company, Inc., New York, 1940.

This comprehensive and illuminating volume is concerned primarily with the more highly specialized forms living at the expense of other insects. It is an indirect result of governmental interest during recent years in attempting to secure control of established foreign insects through the introduction of parasitic or predacious species. Earlier entomologists gave some consideration to possibilities in this direction but in those days limited funds made extensive field work out of the question. The appearance of the gipsy moth, the European corn borer and the Japanese beetle in the East created a strong sentiment in favor of exploring the native countries of these pests for natural enemies in the hopes that the striking results obtained in the 1880's with the cottony cushion scale and its Australian lady beetle enemy might be duplicated to some extent with more recent foreign introductions. It was this condition which resulted in the author of this book being commissioned to explore in the Far East for parasites of the Japanese beetle and later eventuated in his being put in charge of the government parasite introduction work. This book "represents, as nearly as possible, what the author himself would have liked to have had available while engaged in field work upon insect parasitology and the biological control of insect pests." Readers of this volume must concede that the author has realized this aim to a highly satisfactory degree.

This work brings into a connected whole our knowledge to date of parasitic and predacious insects and is especially valuable because it covers all literature, foreign as well as domestic. The forty-seven pages of references give an idea of the labor involved in the preparation of this volume and the dates of the numerous citations indicate that this phase of entomology has been developed largely in the past twenty years. The twenty-eight pages of the index, each with over one hundred and twenty lines, indicate the great number of species noticed. This has necessarily made the text factual and condensed. The book is an introduction to a comparatively unknown and important field of applied entomology since a knowledge of parasites and predators and their ways is of primary importance in the searching out and establishment of natural enemies. Incidentally, in the reviewer's opinion there is much yet to be done along these lines.

The author has been concerned largely with the parasitic Hymenoptera presumably because the more valuable species were more likely to be found among them than in other groups. More than half the volume, 340 pages, are devoted to the four-winged parasites. The Diptera come next with 142 pages. The extended discussions of these two groups indicate in a general way their relative importance as natural controls of other insects. The records contain numerous interesting data relating both to the morphology of the immature stages and to biological adaptations, the former of great assistance in identification and the latter essential to successful collecting, rearing, and establishment in new areas. The diversity of larval form is amazing and must prove a revelation to most entomologists who are acquainted through literature or by field examination with but a few parasitic forms. How did the far eastern Eurytoma learn to depend upon a species of Chrysis for drilling the Monema cocoon, see page 207. Why should a species parasitic upon ants elect to deposit its eggs in cotton squares? How did Psilogaster learn to deposit its eggs in a cluster surrounding the eggs of a Selenothrips placed in the underside of a fleshy leaf? The planidia of this parasite, as many as fifty-three in some cases and exceeding by several times the weight of the carrier, depend on the young thrips for conveyance to an unknown ant host. The prolificacy of some parasites is indicated by the following. A species of Kala has been known to deposit ten thousand eggs, the polyembryonic *Litomastic truncatellus* produces a maximum of three thousand eggs. These are but a few of the facts given in relation to Hymenoptera and Diptera.

The largely predacious habits of the Coleoptera are summarized in 61 pages, Lepidoptera in 14 pages, while the peculiar Strepsiptera are allowed 25 pages. The remaining orders from the Hemiptera through to the Thysanura occupy but 22 pages. The relations to the hosts in these groups are relatively simple although certain species, especially Coccinellids, are important natural controls. The citations in connection with the accounts of the various groups make it relatively easy to consult the literature.

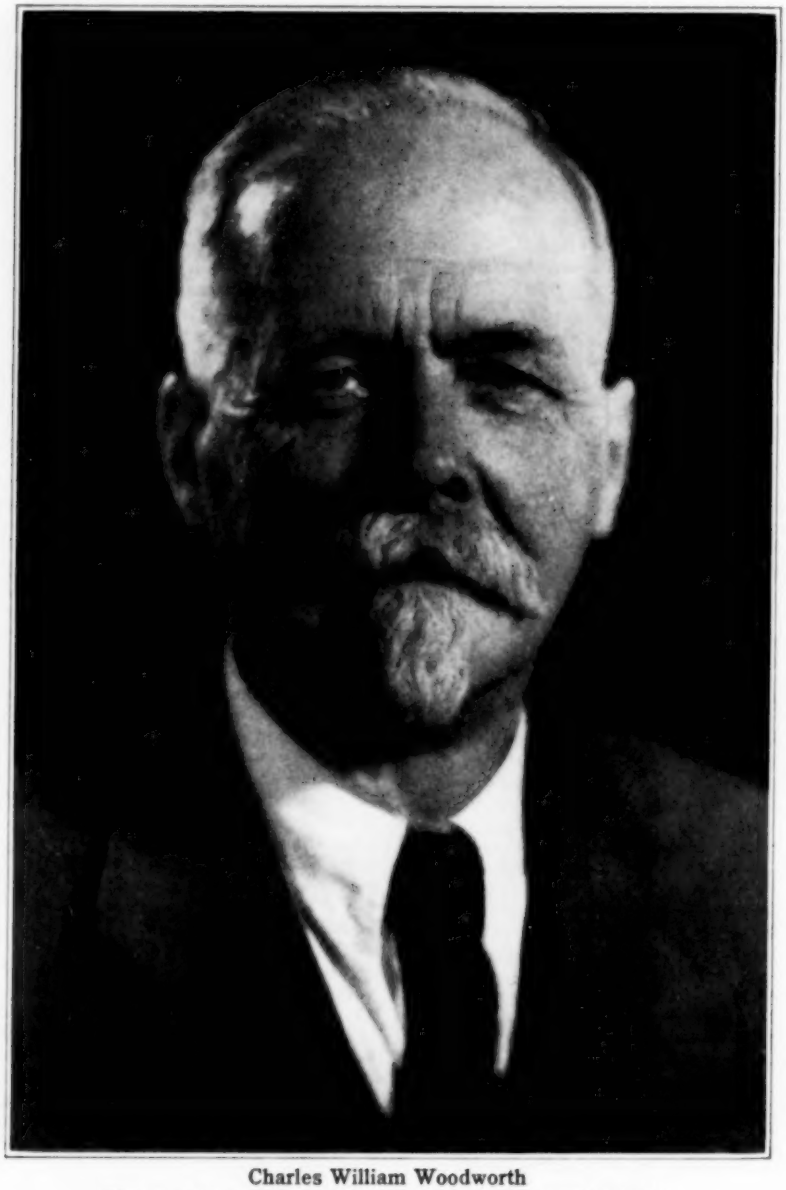
The author has been concerned principally with the types of parasitism and the varied facts bearing upon such activity. He is to be congratulated upon producing a most readable volume and making available an admirable introduction to one of the newer fields of economic entomology. It is a book which should be in every entomological library and is of interest to biologists as well.—1-22-41.

E. P. FELT

OBITUARIES

Charles William Woodworth, 1865–1940

Charles William Woodworth, charter member of the American Association of Economic Entomologists, died at his home in Berkeley, California, November 19, 1940. He was born at Champaign, Illinois, April 28, 1865. Following his graduation with the B.S. degree at the University of Illinois in 1885 he became a graduate student there and an assistant to Dr. S. A. Forbes, one of the greatest American leaders in Entomology. After obtaining the M. S. degree there in 1866 he further pursued graduate studies at Harvard University under Professor E. L. Mark, Chairman of the Division of Biology, and did research work with Dr. H. Hagen during the periods 1886–1888 and 1900–1901. It was here that he wrote the paper on "The Wing Veins of Insects," which was subsequently published in 1906. His first permanent position was as entomologist and botanist at the Arkansas Agricultural Esperiment Station from 1888–1891. In 1891 he moved to California and since that time has held the following positions: assistant



Charles William Woodworth

(Photograph by Coleman, 1937. Furnished by the University of California)

professor of entomology in the University of California, 1891; associate professor, 1904; professor, 1913; professor emeritus, 1930; and head of the Division of Entomology until 1920; lecturer at the University of Nanking, 1918; and honorary professor of entomology at the National Southeastern University at Nanking, China, 1922-1924; organizer and head of the Kiangsu Provincial Bureau of Entomology, 1922–1924; and chief entomologist for the California Spray Chemical Company, Berkeley, California, 1930–1932. In connection with the last-named organization he spent a year of travel in South America. He was the first editor and first contributor to the University of California Publications in Entomology which is devoted chiefly to systematic entomology.

Professor Woodworth had many interests besides entomology which included general biology, ecology, mathematics, physics, chemistry, and many other fields. He was an inventor of considerable ability. Some of his activities in these matters have been reported on elsewhere and only the more important contributions to entomology are considered in this brief review. Although he worked extensively in systematic entomology, as indicated by the many papers listed in his bibliography, he was even more interested in the biological and toxicological aspects of economic entomology. He sought to aid the farmer by every means at his command and traveled repeatedly over much of the State in a personal administration of his office through direct contacts with the many field problems. Much of the work done under his direction was on a cooperative basis between the farmer or orchardist and a representative of his office. Thus were undertaken and solved to a remarkable degree, for that time, such projects as the peach twig-borer, the California peach-tree borer, the potato tuber moth, the grape leafhopper, the codling moth, red spiders, silk culture, tussock moth, Argentine ant, and many others. He took a leading part in the investigations of insecticides and encouraged the early use of paris green and other arsenicals and, with E. E. Luther and W. H. Volck, he had a great deal to do with the experimental and practical development of standard and basic arsenate of lead. Early realizing the poor results often obtained in codling moth control due to the adulteration of paris green, he proposed, wrote, and became the enforcing officer of the first insecticide law passed in California in 1911.

Under his direction, W. H. Volck conducted the important investigations with the use of distillate oil sprays on citrus trees in Southern California in 1901–1903, which paved the way for the work continued by Volck, E. E. Luther, H. J. Quayle, Geo. P. Gray, E. R. de Ong and others which revolutionized spraying procedure even to the present time. As a fitting climax to his long concern in the development of the uses of highly refined petroleum oils, Professor Woodworth, during the last few years, invented and patented a new process for the distillation of petroleum oils at low temperatures.

His interest in cyanide fumigation of citrus orchards began upon his arrival in California and found expression in his first bulletin on fumigation published in 1899. This work no doubt was responsible for his being invited to Florida in 1901 by H. A. Gossard to assist in establishing fumigation methods for the treatment of the citrus whitefly in that State. He was the first to use marked tents and to "recommend a dosage system based on the dimensions of the tented trees. In Professor Woodworth's table of dosage [1903] . . . the amount of cyanid was directly proportional to the cubic contents." He was also the first to recognize the importance of tent leakage and to allow for it in dosage estimates. His figures, published in 1903, show marked tents and he issued several papers on tent leakage and invented a leakage gauge for testing tent materials.

Professor Woodworth was a man of many sterling qualities and the very personification of honesty, kindliness, modesty, and tolerance. He fathered, to a considerable extent, many of his students and gave them more than the credit they earned and deserved. I do not recall that he ever added his name to the publication by a single student or by an assistant. He was extremely tenacious in what he believed to be right.

In addition to membership in organizations in other fields of science, he was a fellow of the American Association for the Advancement of Science, an honorary member of the Entomological Society of America, a member of the Cambridge Entomological Club (president, 1891), and the founder and first president of the Pacific Slope Association of Economic Entomologists which became the Pacific Slope Branch of the American Association of Economic Entomologists in 1915.

At Rolla, Missouri, September 4, 1889, he was married to Leonora Stern, who was the mother of his four children: Lawrence Ariel Woodworth, mining engineer; Harold Evans, entomologist and agriculturist; Charles Edward, entomologist and member of the U. S. Bureau of Entomology and Plant Quarantine; and Elizabeth Woodworth Plass; all of whom survive him. Following the death of his wife in 1924 he was married in 1926 to Bernice Christopher who died in 1930. 1-28-41. E. O. ESSIG

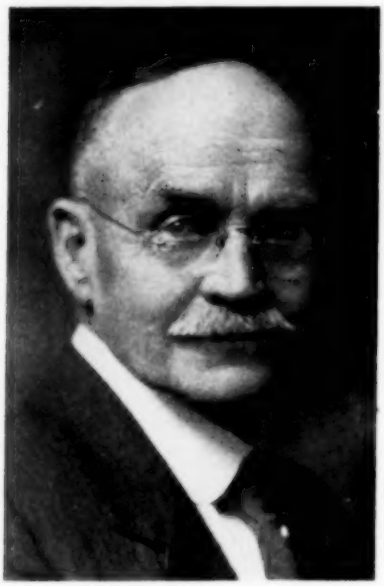
Clarence Preston Gillette, 1859–1941

Clarence Preston Gillette was born April 7, 1859 at Maple Corners, Ionia County, Michigan, the son of William Henry and Larissa Esther Preston Gillette, and died at his home in Fort Collins, Colorado, January 4, 1941. He was a descendant of the French Huguenot family of Gillette, members of which came to Massachusetts in 1630. He married Clara Smith at Portland, Michigan, March 31, 1886. Two daughters survive, Miss Esther Gillette of Cleveland, Ohio, and Mrs. Florence Malcouronne of Fort Collins, Colo., with whom Dr. Gillette has lived since Mrs. Gillette's death.

Dr. Gillette received his bachelor's degree from Michigan State College in 1886 and his master's degree the following year. The same institution conferred the honorary degree of Doctor of Science upon him in 1916. He was the first assistant employed in the Michigan State College department of Zoology, which position he left in 1888 to become entomologist of the Iowa State College Experiment Station at Ames, Iowa. In 1891 he was called to take charge of a new department of Zoology, Entomology and Physiology in the Colorado Agriculture College, now Colorado State College. He arrived in Fort Collins February 7 and for almost fifty years was a very definite influence in the up-building of the commu-

nity, the college and the state. In 1907 Dr. Gillette became Colorado's first state entomologist. He filled that position for 24 years in addition to his college duties and the work which came, July 1, 1910, when he was made director of the Colorado Experiment Station. Dr. Gillette became director emeritus of the experiment station September 1, 1932. During the last several years of his active service he was also vice-president of Colorado State College.

He was a fellow of the American Association for the Advancement of Science, a fellow of the Entomological Society of America, a charter member of the American Association of Economic Entomologists and its president 1901, honorary member of the Iowa Academy of Science, member of the Colorado-Wyoming Academy of Sciences, the American



CLARENCE PRESTON GILLETTE

Genetic Association, and the American Eugenics Society. He was chairman of the Rocky Mountain Conference of Entomologists from its organization in 1923 until 1939, when he was made honorary chairman. He was a member of the honorary societies of Sigma Xi, Phi Kappa Phi and Alpha Zeta, and for many years a member of Rotary International.

Dr. Gillette was probably best known in the field of entomology by his work with Cynipidae, Cicadellidae and Aphidae. His last major piece of work, which was done jointly with Miss Miriam A. Palmer, resulting in the Aphidae of Colorado, is recognized as one of the outstanding works on this difficult group. A complete list of his publications is too long to give here. Coming as he did into a virgin territory he found that problems were numerous. His early reports are full of "first experiences" with new problems. He was a tireless collector and one always marvelled at his memory as to just where and when he had taken a certain species. Even after administrative duties became very heavy, if he was not at his office promptly, it was most likely due to his taking the long route from his home in order to do some collecting or make certain observations. His student collection made at Michigan State College became the nucleus of the Colorado State College collection. It was developed into a well balanced collection, regardless of an intense interest in certain groups that might have caused neglect of others. His careful evaluation of new problems and a sane judgment on their solution made him always in demand as a writer and speaker.

Dr. Gillette's interests were not limited to entomology. The subjects of genetics and eugenics were favorties. The courses in these which he taught until his retirement were among the most popular given in the institution. He was a great student of the history of the Bible and collected many books on this subject. His Sunday school class was always well attended and was known for its open and free discussion. For almost 50 years he was a member of the Board of Trustees of the First Presbyterian church of Fort Collins and just shortly before his death was made an honorary member of this body.

Dr. Gillette was in reasonably good health until the day before his death, when he suffered a stroke. However, during the last several years his eye sight had failed rapidly with the result that he had been unable to read for some time. It was beautiful to see his adjustment to this condition. When he realized this was approaching he learned the touch system for the typewriter, which enabled him to continue correspondence with friends, and to prepare several short articles. He also prepared an autobiographical sketch for his children and grandchildren. He and his brother, who suffered a similar affliction, learned to weave rugs and got a great pleasure out of making these for friends. He kept unusually well informed on current events through the radio and low speed talking records. Many excellent books made into the talking records were read. He became very much interested in the problems of the blind and one of his greatest pleasures was in making his talking edition of the *Readers Digest*, which a group of his friends had given him, available to others each month.

He was a wise administrator. His regime as director of the experiment station was marked by a steady healthy growth. Great freedom was given research workers. Seldom was this taken advantage of but, instead, with the sense of freedom came a sense of responsibility. A kindly interest made the humblest worker feel that he counted.

Dr. Gillette was a modest and almost retiring individual, but yet an inspiring teacher. He seemed to strike a responsive chord in almost every student. This hold on students came from his sincere example and general helpful spirit. His office door was always open. He was generous with his time and energies, almost to a fault. Under all conditions he maintained a charming reserve that took care of all situations and led many to ascribe to him a sort of sage wisdom. His most earnest wishes for a student or a co-worker were often only suggested in the subtlest way.

No one can realize more than the writer, who spent almost 25 years in an office with Dr. Gillette, how imperfect a picture this brief account is of the life of the teacher, the scientist, the cultured gentleman, the friend whom we knew and loved.

GEORGE M. LIST
Colorado State College

John Stuart Pinckney, 1901–1940

John Stuart Pinckney, of the Bureau of Entomology and Plant Quarantine and for many years a member of this Association, died suddenly of a heart attack at Carlisle, Pa. on December 12.

Mr. Pinckney was born at Mr. Pleasant, South Carolina, close to Charleston, where his early life was spent. He was graduated from Clemson Agricultural College in 1921. That same year he entered the service of the Bureau of Entomology, Division of Cereal and Forage Insects, and was attached to the research staff at the Wichita, Kansas laboratory. While there he married Miss Shirley Goodnough of Nevada, Missouri, who survives him.

In January 1929, after a few months voluntary separation from the Bureau, he was reinstated with the title of Assistant Entomologist and assigned to research on hessian fly at the Carlisle, Pennsylvania, laboratory. In 1934, he initiated investigations on the life history and control of *Bruchus brachialis*. This work he conducted for several consecutive summers in the vetch growing sections of North Carolina and brought the project to a satisfactory conclusion, publishing a comprehensive paper in the JOURNAL OF ECONOMIC ENTOMOLOGY in August 1937. He was also joint author of two publications dealing with the fumigation of vetch seed for vetch bruchid control. Besides these investigations he was actively engaged up to the time of his death with various phases of the hessian fly problem, studies of which he had begun in Kansas. In this connection he became junior author of two recent Federal Bulletins on the parasites of the hessian fly.

Mr. Pinckney was a member of the Officers Reserve Corps and at the time of his death was awaiting call for active duty as Major of Infantry of the Third Corp Area.

The untimely death of a man, whose friendliness, integrity and ability won the love and esteem of all, has brought to a close a career which promised to be most brilliant.

In addition to his wife he is survived by his parents, Capt. B. G. and Mrs. Elizabeth Boyd Pinckney of Charleston, S. C. and a sister, Mrs. Carolyn Hennessy of the same city.—C. C. HILL.

C. W. Leng

The death on January 25 of Charles William Leng has been announced. Mr. Leng was well known to entomologists as the author of the Check-list of the Coleoptera and co-author, with W. S. Blatchely, of the Rhynchophora of Northeastern America, as well as many other publications. At the time of his death Mr. Leng was Director of the Public Museum of Staten Island, New York. He was in his eighty-second year, having been born April 6, 1859.

CURRENT NOTES

FLORIDA ENTOMOLOGICAL CONFERENCE

The Sixth Annual Florida Entomological Conference will be held at the University of Florida, Gainesville, Florida, on March 27 and 28, 1941. The Newell Entomological Society sponsors this annual convention of Florida Entomologists and their visitors.

The conference this year will stress the quarantine phase of Entomology and the meetings will be in the nature of a celebration of the 25th Anniversary of the creation of the Florida State Plant Board.

The annual banquet, on March 27, will be in honor of Dr. Lee A. Strong, Chief of the Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

Quarantine officials and other entomologists from all states, Canada, and South American Republics are to be invited.

PACIFIC SLOPE BRANCH MEETING

The meetings of the Pacific Slope Branch of the A. A. E. E. will be held at the California Institute of Technology in Pasadena on June 18, 19 and 20, in conjunction with the meetings of the Pacific Division of the A. A. A. S.

Among the topics of special interest on which there will be discussions and invitational papers are the following:

Rotenone Insecticides
Insect Quarantines
Vegetable Insect Problems of the Pacific Southwest
Forest Insect Problems of the Pacific Coast
Oil Sprays

There will be a symposium in the nature of a Quiz Program on systematic entomology.

No special demonstrations have been arranged, but there will be an exhibit of entomological laboratory apparatus and teaching equipment.

REGIONAL PEST CONTROL CONFERENCES

The Fifth Annual Pest Control Operators' Conference was held at Purdue University, January 6–10, with nearly 100 operators from 16 states attending. Prof. J. J. Davis was in charge of the Conference.

The First Pest Control Operators' Conference for the Eastern States was held at Massachusetts State College, January 13–15, under the direction of Prof. C. C. Alexander. Approximately 100 operators attended. With the inauguration of the first Conference in the East, the four Regional Conferences covering the entire United States and Canada are now in operation.

The Third Conference for the South was held at Louisiana State University, January 27–29, under the direction of Prof. O. W. Rosewall.

The Fourth Conference for the Pacific Slope is scheduled for February 20–22 at the University of California with Dr. W. B. Herms in charge.

Prof. J. J. Davis of Purdue University and W. E. McCauley of the Illinois Natural History Survey, attended the First Eastern Conference of Pest Control Operators held at Massachusetts State College, January 13–15. Both took part in the meetings and Professor Davis was toastmaster at the Conference banquet.

Because of the finding of pear psylla in Chelan and Okanogan Counties, Washington, quarantine order No. 317 of that State was amended November 12, 1940, bringing parts of these counties under regulation.

PROCEEDINGS OF THE ANNUAL MEETING FOR 1940

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS

Hotel Benjamin Franklin, Philadelphia, Pa., December 27–32, 1940

At the Philadelphia meeting 339 entomologists registered for the session starting Friday, December 27 and closing Tuesday, December 31.

Fortunately the program of papers for the General Sessions was not quite so long as usually, but the programs of the Sectional meetings partly made up for this and those in attendance had every minute taken up.

The excellent Public Address of the Entomological Society of America was delivered by R. E. Snodgrass at the Philadelphia Academy of Sciences. The subject, "Evolution of the Arthropods," drew an audience that filled the Academy auditorium. After the address the Academy and the American Entomological Society entertained the visiting entomologists in the library of the Academy with an informal reception.

The outstanding character of Harry S. Smith's presidential address on "The Segregation of Insect Populations into Races and Its Significance in Applied Entomology," presaged a program of great interest. A symposium presided over by P. N. Annand, in which both entomological societies participated, on the Breeding of Cultivated Plants Resistant to Insect Attacks, was attended by a large audience. The following were the topics and speakers:

The place and method of breeding for insect resistance in cultivated plants. R. O. Snelling.

Breeding plants for resistance to insect attack:

Corn.—J. H. Bigger;
Wheat and Alfalfa.—C. M. Packard;
Vegetables.—S. F. Bailey.

The economic value and biologic significance of plant resistance to insect attacks, R. H. Painter.

The Extension Section conducted its meetings on the basis of two panel discussions of methods and coordination. Entomologists interested in Tobacco Insects met early on Friday to coordinate their recommendations.

The Entomologists' banquet, attended by 371 persons, was ably presided over by Dr. Calvert. The Eastern Branch Medal, for the outstanding paper delivered at the Atlantic City meeting, was presented to Dr. P. J. Chapman, G. W. Pearce, and A. W. Avens, for their paper on "The Use of Petroleum Oils as Insecticides. Factors Affecting the Amount of Oil Deposited on Apple Bark in Dormant Spraying." Dr. Martin Grabau of the Polaroid Corporation discussed polarized light and demonstrated some of the stereoscopic effects obtained in its use.

Even Sunday was utilized for conferences and special sessions. The Taxonomists and those interested in biological control held separate meetings, and the Teaching Section began its meeting at 1:30, recessed at 5, and continued a most interesting and instructive program during the evening.

On Monday, in addition to the General Session, which began at 1:30 with a business meeting, the Section of Plant Quarantine and Inspection had an unusually large attendance. The Apiculture Section met at night, and the Pea Aphis Conference, with a short program of four speakers, attained a new high in attendance and interest. By holding the business session one day before adjournment, a large attendance was achieved, thereby making possible the participation of all interested members in the conduct of the affairs of the Association.

The Local Committee consisting of J. A. G. Rehn, P. Glen Richards, H. F. Dietz, and C. H. Hadley, Chairman, made most satisfactory arrangements for every occasion so that the convention ran smoothly and efficiently. The exhibit staged by C. A. Clark was varied and extensive and proved to be the focus of interest of many in attendance. The Hotel Benjamin Franklin provided every facility, convenience and courtesy.

BUSINESS MEETING, DECEMBER 30, 1:30 P.M.

The report of the Auditor was read by the Secretary, who suggested that a complete statement be read and published every 5 years, and a brief statement be made other years. The Secretary pointed out that some items were carried over from 1939. On November 15 a number of members were in arrears, the total amounting to over $1,300. Practically all of this sum has now been collected and there are very few in arrears at this time. The Secretary moved the acceptance of the Auditor's report and the publication of the schedules covering receipts and disbursements and the permanent fund in the February JOURNAL. This was seconded by Dr. Annand, and carried.

The Secretary then explained that there had been an open Executive Committee meeting on the night of December 29 at which were received reports of various committees, both the official standing committees and special committees appointed by the President during the year. Also, certain suggestions were made at the open meeting as a guide to the Executive Committee. The Executive Committee went into session after the open meeting and approved certain parts of certain reports, accepted others in toto, and acted upon a few other matters that did not appear in any of the reports.

RECOMMENDATIONS OF THE EXECUTIVE COMMITTEE

1. The enlargement of the Committee on Membership by the addition of one member from the Southwest.

2. The election of the Chairman of the Committee on Popular Entomological Education for a period of three years.

3. The retention of one member of the current Nominating Committee on the new Nominating Committee to be appointed by the incoming President.

4. The contribution of $15.00 to help defray the cost of the clerical work of the Union of American Biological Societies.

5. The adoption of the report of the Publications Committee with certain modifications.

6. The changing of the closing date of audit from November 15 to November 30.

7. The fullest cooperation with the National Resources Planning Board in the codification and allocation of entomological workers.

8. The publication in the spring of 1941 of Index VI under the editorship of Dr. E. P. Felt.

9. The acceptance of the report of the Committee on Inter-American Entomological Conference, which carries with it the idea of a Committee instructed to explore the possibilities of some cooperative endeavor to effect the general purpose of closer cooperation with American Republics.

10. Acceptance of the report of the Committee on the Summer Meeting at Durham, New Hampshire, with the understanding that they develop the idea of the Symposium on Experimental Methods in Insecticidal Control.

11. Adoption of the report of the Committee on Biological Monographs and the selection of a special committee consisting of Leslie Campbell as Chairman and L. M. Peairs with the power to select three additional members to be selected for their broad knowledge of entomology in general and their familiarity with specialized fields.

12. The selection of San Francisco as the convention city for 1941, with the starting date Monday, December 29.

13. That due to insufficient undedicated income the idea of loan scholarships be deferred and the Committee discharged with thanks.

The report was adopted after considerable discussion of the report of the Publication Committee, a stenographic record of which was kept.

The Publication Committee nominated the same Journal officers for the year 1941. The report was accepted and the nominations included, though not read a third time, in the report of the Nominating Committee.

An adjourned business session was held on December 31 at which time routine details, including approval of officers nominated by the sections, were completed.

COMMITTEES APPOINTED—1940

The following committee appointments were made during the year by President Smith:

NOMINATIONS—W. P. Flint, *Chairman*
A. S. Hoyt
S. B. Freeborn

RESOLUTIONS—C. J. Drake
H. A. Allen
H. F. Bailey
W. D. Reed
P. J. Readio

INTER-AMERICAN CONGRESS—E. R. Sasscer, *Chairman*.
M. D. Leonard
H. B. Weiss

SUMMER MEETING—W. C. O'Kane
C. E. Palm
F. H. Lathrop

COMMERCIAL EXHIBITS—Ernest N. Cory, *Chairman*
W. S. Hough
J. R. Horsfall
H. F. Dietz
L. A. Stearns
S. A. Rohwer
A. E. Badertscher
T. J. Headlee

COUNCILLORS, AAAS—W. S. Hough
C. P. Clausen

SCHOLARSHIPS—John T. Creighton

AMERICAN SCIENCE CONGRESS—C. P. Cluasen
F. C. Bishopp
Ernest N. Cory

MONOGRAPH COMMITTEE—P. N. Annand
Leslie Campbell

REPORT OF THE SECRETARY-TREASURER

The total membership as of November 15 was 1,320. During the year there have been 5 deaths, 13 resignations, 11 reinstatements, mail returned from 15, and 12 dropped for non-payment. At the last meeting 161 new members were added, and at this time there are 121 applications in my hands. The net membership therefore is 1,536.

It is only fair to expect a reduction in the number of subscribers in the years ahead owing to the difficulty of securing delivery to certain countries. Our publisher has been advised to hold copies of the JOURNAL that the company thought could not be assured of safe delivery. These JOURNALS will be delivered to the subscribers when conditions improve.

Compilation of Index VI has been completed by Miss Colcord and is now in the hands of the Taxonomic Unit of the Bureau of Entomology and Plant Quarantine for checking of the technical names. It will be placed in the hands of Dr. Felt, who has consented to edit the volume, and should be ready for publication in the early spring. The manuscript is about 30 per cent greater than for Index V.

The book accounts of Indices I to IV have been consolidated and show a net credit of $1,395.76 to that account. Since the cost of each Index originally was borne by the Association, it is apparent that over a period of years the indices have repaid their cost and have returned to the Association the amount specified. The book deficit of $1,562.50 charged to Index V represents approximately the difference between the cost of publication and the sum set aside from dues to permit the free distribution of the index to members in good standing. All bills, of course, have been paid, and upon the publication of Index VI, for which a fund is being set up from dues, the accounts of Volume V will be consolidated with that of I–IV, whereby the deficit will be almost offset by the credit of Indices I–IV.

The quality and number of the articles, the format and the technical excellence make the Journal outstanding among scientific journals. It is printed primarily as a service to the membership and as such the effort has been made to increase its usefulness in every way. The subscription price is too low, but since it is printed for the members, the use of Association funds to supplement JOURNAL revenues is amply justified. The JOURNAL for this year, as compared with 1939, has been published at approximately the same cost per page.

In examination of the auditor's report, it must be borne in mind that since the books were closed November 15, there is always a carry-over of items paid after the audit date, such as publishing costs of the December number; and included in this year's audit, October 1939 as well. It is not possible to have a complete all-inclusive report ready for November 15. Therefore, as a step towards greater efficiency the auditor has suggested changing the closing date to November 30 of each year.

The Association has a working balance of $5,589.12 and permanent funds of $23,511.42. The audit shows $1,500 increase in permanent funds plus interest of $674.54. Actually the transfer of $1,500 took place in the previous year. The auditor shows it again because the Treasury Department required the Association to turn in the bonds for credit. That sum then appeared in the cash account in place of the $1,500 in Savings Bonds.

It is apparent that the enlargement of the Committee on Membership and the Committee on Popular Entomological Education were moves in the right direction. Enlargement of the former enables a better canvass of the prospective members and the policy might be carried further by designating a member from the Southwest, say from Texas.

P. D. Sanders, as Chairman of the Committee on Popular Entomological Education, has made an excellent start in getting entomological information into our farm periodicals and is making arrangements for local publicity in Philadelphia. If we are to expect continuity of effort in this direction, it would seem advisable to elect the chairman of this important committee for a three year period.

The request of one insecticide manufacturer to exhibit at the annual meetings brought up the question of commercial exhibits. President Smith appointed the writer as Chairman of a committee to study the question and report at the annual meetings. Messrs. Dietz, Horsfall, Badertscher, Hough, Stearns, Headlee and Rohwer were asked to sit on the committee, which met at Atlantic City. Some who could not be present had expressed their views and several other members were asked to sit in on the deliberations.

It was finally adopted as the sense of the meeting that no effort should be made to encourage or solicit commercial exhibits, but that any exhibit of outstanding educational value should be accepted from any commercial concern, provided the installation, etc. is made at no cost to the Association.

The Association has established cooperation with the National Resources Planning Board through the development of codes of workers in entomology grouped in special categories. The Association has addressed envelopes for the National Resources Planning Board to each of our members and has fornished the National Resources Planning Board with a card file of members for use in coordinating entomological activities, especially along defense lines.

There are a number of questions in regard to JOURNAL policy that need clarification. In the old days only members could deliver addresses at the annual meetings. No proxy delivery was allowable. Only members were allowed to publish free of cost, up to the maximum page allowance. With the invitation programs on which non-members have appeared and the practice of prior publication by paying the costs, this policy has been somewhat altered. The Editor would welcome a restatement of policy which the present conditions seem to make desirable. In passing, it might be well to mention the new policy of indexing scientific contributions and to urge greater use of this medium for early publication and to call to mind the desirability of short notes in regard to persons and events that can often be used to advantage in filling out pages.

The Executive Committee this year authorized the payment of the Canadian War Exchange Tax after the Secretary attempted without result to secure a remission of this fee. This amounts to approximately to 5½¢ per copy on all subscriptions going into Canada. The tax must be paid at the source or publications must be held up at the border until the tax is paid by the subscriber. Since our Canadian members are already penalized on account of the difference in exchange, it is recommended that the War Exchange Tax be paid by the Association.

ERNEST N. CORY, *Secretary*

FINANCIAL STATEMENT

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS CASH RECEIPTS AND DISBURSEMENTS** FOR THE FISCAL YEAR ENDED NOVEMBER 15, 1940

Exhibit "C"

For the fiscal year ended November 15, 1940

	TOTAL	JOURNAL	ASSOCIATION	INDICES I–IV	INDEX V	INDEX VI
Receipts:						
Subscriptions	$ 6,204.18	$ 6,204.18				
Adveritising	397.43	397.43				
Reprints	1,994.09	1,994.09				
Back numbers	223.43	223.43				
Dues	2,427.70		$1,820.78		$12.80	$594.12
Sales	105.50			$50.50	55.00	
Interest on bank depositis	25.27		25.27			
Miscellaneous	55.66	30.12	25.54			
Total Receipts	$11,433.26	$ 8,849.25	$1,871.59	$50.50	$67.80	$594.12
Disbursements						
Auditing and accounting fees	$58.50	$11.75	$46.75			
Surety bond for secretary	12.50		12.50			
Printing	8,253.14	8,038.49	214.65			
Engravings, drafting, etc.	995.11	995.11				
Editor's salary	300.00	300.00				
Assistant to the Editor	150.00	150.00				
Salary, Secretary and Business Manager	575.00	287.50	287.50			
Stenographic services, Secretary	126.50	63.00	63.50			
Clerical work	141.00	99.10	41.90			
Traveling expenses: E. N. Cory	135.72		135.72			
H. S. Smith	343.54		343.54			
P. D. Sanders	15.51		15.51			
Convention expenses	138.00		138.00			
Branch expenses: Cotton States	67.69		67.69			
Plant Quarantine expenses	13.17		13.17			
Postage, stationery and supplies	377.06	147.53	228.88		.65	
Telephone and telegraph	119.21	14.88	104.33			
Express	3.88	2.35	.30	.30	.93	
Service charges	11.57	5.78	5.79			
Refunds	55.46	53.46	2.00			
Filing equipment	117.50		117.50			
Miscellaneous	5.35	.35	5.00			
Total Disbursements	$12,015.41	$10,169.30	$1,844.23	$ .30	$1.58	—
Excess of Receipts; Excess of Disbursements*	$ 582.15*	$ 1,320.05*	$27.36	$50.20	$66.22	$594.12
Cash Balances, November 15, 1939	7,721.27	4,622.79	3,955.04	$1,345.56	$2,675.91*	473.79
Adjustments:						
Credit to Index V for ¼ of Dues Rec'd in 1937 & '38			1,047.19*		1,047.19	
Life Memebership Rec'd in '38 & Credited to Asso.	50.00*		50.00*			
Transfer to Permanent Fund	1,500.00*	750.00*	750.00*			
Cash Balances, November 15, 1940	$ 5,589.12	$ 2,552.74	$2,135.21	$1,395.76	$1,562.50*	$1,067.91

The balance is represented by the following:

Prince Georges Bank & Trust Company, Hyattsville, Md. (checking account)	$3,715.13
First National Bank of Amherst, Mass. (savings account @ 1½%)	1,703.30
Cash on Hand	170.69
Cash Balance, November 15, 1940 (as above)	$5,589.12

* Indicates debit or deficit.

** This statement does not include Cash Receipts of the Permanent Fund. This information may be found in Exhibit "D."

LETTER FROM THE AUDITOR

Dr. E. N. Cory,
College Park, Maryland

College Park, Maryland
December 9, 1940

Dear Dr. Cory:

I have examined the accounts of the American Association of Economic Entomologists for the fiscal year ended November 15, 1940. The results of the examination have been set forth in the following exhibits and schedules which are on file at the office of the secretary as part of the association's permanent financial records.

Exhibit "A" Balance Sheet, November 15, 1940.
Exhibit "B" Statement of Profit and Loss.
Exhibit "C" Statement of Receipts and Disbursements.
Exhibit "D" Statement of Permanent Fund, November 15, 1940.
Schedule 1 Statement Showing Adjustments from Cash to Accrual basis.
Schedule 2 Subscriptions Receivable, Non-members.
Schedule 3 Subscriptions and Dues Receivable, Members.

In accordance with the customary practice of the association only statements "C" and "D" have been designed for publication and are herewith submitted as evidence of the financial transactions of the association for the fiscal year ended November 15, 1940.

I hereby certify that, in my opinion, these statements are a correct presentation of the financial condition of the American Association of Economic Entomologists.

Respectfully submitted,
(Signed) CHARLES L. BENTON, JR.
Certified Public Accountant

AMERICAN ASSOCIATION OF ECONOMIC ENTOMOLOGISTS
STATEMENT OF PERMANENT FUND FOR THE PERIOD FROM NOVEMBER *30*, 1939 TO NOVEMBER *15*, 1940

Exhibit "D"

Balance, November 30, 1939, as per previous report			$21,331.88
Income for the period:			
Interest received from securities		$267.50	
Interest received from savings deposits:			
Prince Georges Bank & Trust Company	$38.60		
Franklin County Trust Company	23.44	62.04	
Interest credited to book value of U.S. Savings bonds		300.00	
Transferred from Association Funds—Life membership received on December 22, 1938 and credited to Asso. at that time		50.00	
Total Income			679.54
Transferred from Association Funds			1,500.00
Balance, November 15, 1940			$23,511.42

The balance is invested as follows:

PAR VALUE	SECURITIES	MARKET VALUE NOV. 15, 1940	BOOK VALUE	
$ 2,000.00	Province of Ontario, 5's	$ 1,980.00	$2,000.00	
2,500.00	U. S. Treasury Bonds, 3¼'s	2,730.75	2,484.00	
3,000.00	U. S. Treasury Bonds, 2⅞'s	3,306.60	2,984.00	
5,000.00	U. S. Savings Bonds, Series A	4,200.00	4,200.00	
10,000.00	U. S. Savings Bonds, Series D	7,700.00	7,700.00	
$22,500.00		$19,917.35		$19,368.00

BANK DEPOSITS (*Savings Accounts*)

Prince Georges Bank and Trust Company, Hyattsville, Md. (2%)	2,953.60
Franklin County Trust Company, Greenfield, Mass. (2%)	1,189.82
Balance of investments (as above)	$23,511.42

REPORT OF COMMITTEES

THE NOMINATING COMMITTEE

The Committee has endeavored to continue the practice already well established within the Association of nominating new men to fill vacancies rather than having anyone succeed himself. There is one exception to this general practice in that the Committee has nominated Dr. Herbert Osborn as Representative on the Board of Trustees of Tropical Plant Research Foundation.

President: J. R. Parker
First Vice President: Leonard Haseman
Executive Committee: C. O. Eddy
Committee on Common Names of Insects:
R. T. Cotton
B. G. Thompson
Committee on Membership:
R. L. Webster, *Chairman*
S. W. Bilsing
Committee on JOURNAL Publications:
C. M. Packard
M. A. Stewart
F. L. Campbell was designated as chairman of the committee
Joint Committee on Insect Collections:
B. E. Montgomery
C. P. Alexander
Program Committee:
D. B. Mackie
Committee on Codling Moth:
W. S. Hough, *Chairman*
L. F. Steiner
George M. List
Committee on Insecticide Terminology:
M. D. Farrar
Joint Committee for the Promotion of Official Entomology:
T. J. Headlee, *Chairman*
Frank N. Wallace
A. M. Boyce
Committee on Popular Entomological Education:
M. P. Jones
Committee on Cooperation with Pest Control Operators:
Roger B. Friend
Committee on Relation of Entomology to Conservation:
F. P. Keen
Board of Trustees of Permanent Fund:
H. G. Crawford
Trustees of Crop Protection Institute:
Charles E. Palm
Representatives on the Council of the Union of American Biological Societies:
A. B. Gurney
Representative on the Board of Trustees of Tropical Plant Research Foundation:
Herbert Osborn

Councilor for the American Association for the Advancement of Science:
T. J. Headlee
Editorial Board of the JOURNAL:
Editor—L. M. Peairs
Honorary Editor—E. P. Felt
Associate Editor—H. B. Weiss
Business Manager—Ernest N. Cory
STANLEY FREEBORN
AVERY S. HOYT
W. P. FLINT, *Chairman*

Since neither the President nor the Vice-President elect was present, Dr. Smith suggested that the Secretary be instructed to advise them by telegram of their election.

Dr. C. L. Metcalf read the report of the Membership Committee which was adopted.

Professor O'Kane spoke for a few mintues in regard to the summer meeting at Durham, New Hampshire, in order to give the membership present some idea of what the meeting would be like.

REPORT OF THE MEMBERSHIP COMMITTEE

One hundred and twenty (121) applications for membership, correctly executed and accompanied by the required fee, have been approved by the Committee on Membership and are hereby recommended for active membership in the Association:

LIST OF MEMBERS ELECTED—1940

James F. Adams, 2900 Harrison St., Wilmington, Del.
Griffith Asplundh, Bryn Athyn, Pa.
J. A. Athelstan, 6745 Grand Ave. S., St. Paul, Minn.
Edward W. Baker, Calzeda Mexico-Tacuba 295, Colonia Anahuac, Mexico, D. F.
Henry H. Baker, State Dept. of Agr., Jefferson City, Mo.
D. F. Barcus, Leesburg, Fla.
C. S. Barnhart, 38 West 9th Ave., Columbus, Ohio
Blair R. Bartlett, Citrus Expt. Sta., Riverside, Calif.
Russell H. Beatie, 6528 Belmont, Houston, Texas
Elmer W. Beck, 51 Banhara Road, Waltham, Mass.
R. Edward Bellamy, 422 East Huron St., Ann Arbor, Mich.
Richard M. Bohart, Div. of Ent., Univ. of California, Los Angeles
Arthur E. Bonn, Box 278, Forest Grove, Ore.
Harry E. Bronson, Apt. JD-2, 10 Monroe St., New York
K. R. Brown, Atlas Powder Co., Wilmington, Del.
Ivor R. Burden, 1148 3rd Ave., Sacramento, Calif.
Glenn E. Carman, Comstock Hall, Cornell Univ., Ithaca, N. Y.
John M. Carpenter, Biology Bldg., Room 9, Univ. of Texas, Austin
Stanley J. Carpenter, 400 Booker St., Little Rock, Ark.
Carroll C. Cassil, Box 1291, Yakima, Wash.
Robert D. Chisholm, 404 North Washington Ave., Moorestown, N. J.
Junius C. Clark, Delta Expt. Sta., Stonerville, Miss.
Sherman Wood Clark, 1002 Second Nat'l. Bank Bldg., Houston, Texas
James H. Cochran, Eupora, Miss.
Charles E. Cody, B. E. Maling Inc., Hillsboro, Ore.
Walter F. Condon, 30 West Palm Lane, Phoenix, Ariz.
Donald P. Connola, Boyce Thompson Institute, Yonkers, N. Y.
Robert L. Crowell, Health & Safety Dept., Wilson Dam, Ala.
Herbert Theodore Dalmat, 233 Sheldon Ave., Ames, Iowa
Herbert A. Dean, 121 North 10th St., McAllen, Texas
James E. Dewey, Dept. of Ent., Univ. of Tennessee, Knoxville
Robert J. Dicke, Dept. Econ. Ent., Univ. of Wisconsin, Madison
George V. Dillard, 609 West Lemon St., Lakeland, Fla.
Irving B. Dobkin, 3435 West 18th St., Chicago, Ill.
Richard L. Doutt, Box 1015, Santa Paula, Calif.
E. T. Doyle, 1 South Park, San Francisco, Calif.
Stuart D. Edmond, Box 32, Durham, N. H.
Paul M. Eide, Box 458, Sumner, Wash.
William H. Ewart, Comstock Hall, Cornell University, Ithaca, N. Y.
Ernest H. Floyd, Agricultural Center, University, La.
Donald B. Fogarty, Box 2703 University Station, Gainesville, Fla.
Edwin H. Fosen, Mission Hall, Yuba City, Calif.
Father Ovila Fournier, 1577 Providence St., Quebec, Canada
Norman W. Frazier, Div. of Ent., Univ. of Calif., Berkeley
Roy Fred Fritz, Ent. Dept., Kansas State College, Manhattan
Robert L. Furniss, 445 U. S. Court House, Portland, Ore.
Garland L. Furr, 5 Sweeny Apts., Brownsville, Texas
Theodore M. Gage, Dept. Zoology & Entomology, Ohio State Univ., Columbus
John R. Garrett, Rm. 844 Federal Bldg., Christopher St., New York
Paul D. Gerhardt, Div. of Ent., Univ. of Calif., Berkeley
Irwin H. Gilbert, 606 Eppley Ave., Zanesville, Ohio
R. E. Griffin, 4514 S. E. 18th Ave., Portland, Ore.
Albert Wendell Grundmann, 1110 Kearney St., Manhattan, Kan.
J. Allan Hall, 315 Main St., Simcoe, Ontario
James William Hansen, Div. of Ent. & Par., Univ. of Calif., Berkeley
Elton J. Hansens, Rutgers Univ., Ent. Dept., New Brunswick, N. J.
Edward Harvill, 1086, N. Broadway, Yonkers, N. Y.
Arthur Mayfield Hill Jr., Box 1123, Vero Beach, Fla.
Roscoe E. Hill, Dept. Ent., Univ. of Nebraska, Lincoln
Carl B. Huffaker, 448 W. 4th Ave., Columbus, Ohio
John H. Hughes, Div. Ent., Univ. of Minnesota, St. Paul
Esler Johnson, 503 Market St., San Francisco, Calif.
George S. Kido, Agr. Expt. Sta. Rt. 1, Box 92, San Jose, Calif.
William A. Knapp, 262 West 107 St., New York
R. Joseph Kowal, 8 Whippany Rd., Morristown, N. J.
Horace Lee, Box 1149, Tallulah, La.
Max J. Levy, 2399 University Ave., St. Paul, Minn.
O. D. Link, Fort Lauderdale, Davie Route, Fla.
Edwin R. Lott, Box 588, Opelousas, La.
I. H. Luttan, 424 West 18th St., New York
Irwin Marks, 58 N. 26th St., Corvallis, Ore.
Harold J. McAlister, Box 171, Charlottesville, Va.

George L. McCall, 48 West 8th St., Corvallis, Ore.
Roy C. Meek, 716-8th St., Baton Rouge, La.
W. H. Mecom, 1412 Commerce Building, Houston, Texas
Seaton C. Mendall, Agr. Expt. Sta., Geneva, N. Y.
James D. Merrill, 201 South St., Smyrna, Del.
Woodrow W. Middlekauff, 240 Linden Ave., Ithaca, N. Y.
Ralph L. Morris, 404 State Library Bldg., Indianapolis, Ind.
Donald M. Muirhead, Washington St., Duxbury, Mass.
Earle C. Murdock, 7209 Pine St., Upper Darby, Pa.
Kenneth B. Nash, Comstock Hall, Ithaca, N. Y.
George Nicolaides, 644 Washington St., New York
Robert J. Norton, U. S. Rubber Company, Market & South, Passaic, N. J.
J. O. Nottingham, Dept. of Ent., Cornell Univ., Ithaca, N. Y.
William O'Reilly, 313 E. 16th St., Minneapolis, Minn.
Frank T. Parmelee, 329½ N. Pine Ave., Lansing, Mich.
Charlie L. Parnell, 12 Zaragoza St., Brownsville, Texas
Benjamin D. Pate, Box 1055, McComb, Miss.
Rezin Z. Pepper, Box 546, Laurel, Miss.
Morton S. Prescott, 608 S. Dearborn St., Chicago, Ill.
J. C. Redd, State College, Miss.
Harry L. Rideout, Box 1468, Yakima, Wash.
R. G. Rosentiel, 953 Monroe St., Corvallis, Ore.
C. L. Ritchie, 422 Federal Office Bldg., Seattle, Wash.
Roger William Roth, 68-19 65th St., Ridgewood, Queens, N. Y.
David B. Scott, Jr., Pennsylvania Salt Mfg. Co., Tacoma, Wash.
Roger Scott, Ent. Dept., Corvallis, Ore.
H. F. Sessums, Box 121, Picayune, Miss.
Harold Schnorrenberg, 1315 N.W. 23rd St., Oklahoma City
Ralph Shemin, B.E.P.Q., Room 844, Federal Bldg., Christopher St., New York
Pedrito Silva, Estacao Geral de Expt., Agua Preta, Bahia, Brazil
George F. Smith, 59 Prospect Place, Brooklyn, N. Y.
Howard W. Smith, Box 323, Durham, N. H.
William Ward Smith, Whitten Hall, Univ. of Missouri, Columbia
Charles A. Snow, 1606 Monte Vista Drive, Whittier, Calif.
Fred M. Snyder, 3563 88th St., Jackson Heights, New York
Chester L. Stanford, 87 Allard Blvd., New Orleans, La.
Charles H. Starker, Dept. of Ent., Corvallis, Ore.
Robert Sutton, Comstock Hall, Cornell University, Ithaca, N. Y.
W. P. terHorst, U. S. Rubber Co., General Development Div., Passaic, N. J.
Frederico Vanetti, ESAV, Vicosa, Minas Geraes, Brazil
William C. Vaughan, Jr., 1905 Kerns Ave., San Marino, Calif.
Junius Daniel Vertrees, 204 Wilder Apartments, Corvallis, Ore.
Carl G. Vinson, 206 Whitten Hall, Columbia, Mo.
George B. Vogt, College Park, Md.
Robert Eugene Wean, Stauffer Chemical Co., 420 Lexington Ave., New York
Allen S. West, Jr., Univ. of New Brunswick, Fredericton
A. L. Williamson, 1716 Grant St., Brownsville, Texas
John W. Wilson, Experiment Station, Belle Glade, Fla.
Curtis W. Wingo, 107 Whitten Hall, Columbia, Mo.
Leland Wolfe, 125 Lafayette Ave., Suffern, N. Y.
William D. Wylie, Forest Home, Ithaca, N. Y.
Willard W. Yates, R. 5, Sherwood, Ore.
Harry D. Young, 1204 Fremont St., Manhattan, Kan.
Harold R. Yust, 534 E. Walnut St., Whittier, Calif.

In addition 14 persons, who were formerly members, have been reinstated. In accordance with previous practice, two members who have presented resignations, because of their long and faithful support of the Association, are being retained as members with remittance of their annual dues.

During the year the Association has lost 8 members by death, 13 by resignation, and 12 who have been dropped for non-payment of dues. The deceased members are:

DEATHS—1940

C. N. AINSLIE: Sioux City, Iowa (Dec. 1939)
E. P. VAN DUZEE: San Francisco, Calif.
J. H. MONTGOMERY: Gainesville, Fla.
R. R. REPPERT: College Station, Texas
R. W. HAEGELE: Parma, Idaho
G. R. WILSON: Alameda, Calif.
J. S. PINCKNEY: Carlisle, Pa.
C. W. WOODWORTH: Berkeley, Calif

The membership at the close of the last year (1939) totaled	1,320
Members added in 1940	136
Members lost during 1940	32
Net gain	104
Total present membership	1,424

Respectfully submitted,
C. L. METCALF, *Chairman*

REPORT OF THE RESOLUTIONS COMMITTEE

1. RESOLVED, That the Association express its regret that conditions made it impossible for many of our highly esteemed Canadian members to attend the Philadelphia meetings as they have done in past years.

2. WHEREAS, The present emergency has brought about the congregation of large groups of men in camps and other concentration points, and

WHEREAS, A number of new foci of activity are being developed in tropical areas, and

WHEREAS, Both of these conditions may produce serious problems of public health involving the transmission of insect-borne diseases such as malaria, typhus, yellow fever, dengue, plague and dysentery,

BE IT RESOLVED, That we place ourselves as an organization at the disposal of any interested governmental agency for advice, consultation or action;

AND BE IT FURTHER RESOLVED, That in addition the attention of the Medical Corps of the Army and Navy be called to the potential source of valuable service in the persons of trained entomologists called and to be called by the Selective Service Administration,

AND BE IT FURTHER RESOLVED, that copies of this resolution be sent by the Secretary to

the Surgeon General of each Service and to the other persons noted below:

U. S. Public Health Service—Surgeon General Thomas E. Parran
U. S. Navy—Surgeon General Comm. Stephenson, C. E.
U. S. Army—Surgeon General James S. Simmons, C. E.

3. BE IT RESOLVED, That the thanks of the Association be extended to C. H. Hadley, C. A. Clark, J. A. G. Rehn, A. G. Richards, and Harry Dietz, the Local Committee, for their excellent arrangements made in connection with this, the fifty-second annual meeting of the Association, and that the Society express its most grateful appreciation to the Academy of Natural Sciences in Philadelphia and the American Entomological Society of Philadelphia for the many courtesies and fine hospitality.

4. BE IT RESOLVED, That this Association extend its thanks to the officers and members of the Academy of Natural Sciences of Philadelphia and the American Entomological Society of Philadelphia for the excellent accommodations provided for the annual public address of the Entomological Society of America, and for the informal reception and open house.

5. BE IT RESOLVED, That this Association extend its thanks to the management of the Hotel Benjamin Franklin of Philadelphia for the excellent accommodations and facilities provided during the meetings.

6. BE IT RESOLVED, That this Association extend its thanks to the Polaroid Corporation and to Dr. Martin Grabau for the most instructive discussion and demonstration of polarized light presented in connection with the annual banquet.

P. A. READIO
STANLEY F. BAILEY
H. W. ALLEN
W. D. REED
C. J. DRAKE, *Chairman*

REPORT OF THE PUBLICATIONS COMMITTEE, JOURNAL OF ECONOMIC ENTOMOLOGY

The Committee met during the meeting of the Association and discussed in detail many problems pertaining to the JOURNAL. Although only three members of the Committee were present, essential approval and no dissenting votes of the following recommendations were received by letter from five members.

The Committee first wishes to commend Dr. L. M. Peairs, Editor of the JOURNAL OF ECONOMIC ENTOMOLOGY, for the efficient and skilled manner in which he has maintained the high standards of the JOURNAL during his first year in this exacting office.

The Committee notes with approbation that the cost of publication per page has not increased over that of previous years; in spite of increasing costs of printing, the favorable contract obtained by the management has been beneficial.

The Committee recommends no change in the sum assigned for use by the Editor for editorial and other assistance.

The Committee recommends the approval of the following policies in the acceptance of papers for publication and style of publication:

1. Papers by non-members who are regularly employed as economic entomologists shall not be accepted for free publication. This rule may apply to papers by joint authors of which a non-member is a contributor. Papers by non-members who are not regularly employed as economic entomologists shall be considered individually on the irmerits. These rules shall not necessarily apply to Scientific Notes.

2. A paper acceptable for publication which will occupy less than two pages of the JOURNAL OF ECONOMIC ENTOMOLOGY in 10-point type, including illustrations or tables, may be published as a scientific note, except as may be agreed upon by the Editor and one member of the Publications Committee. Titles of Scientific Notes shall be included in the table of contents and be indexed.

The Committee submits to the Executive Committee the following resolutions, with the recommendation that they be approved by the Executive Committee and submitted to the Association:

RESOLVED, That the American Association of Economic Entomologists reaffirms the policy established by long usage that papers accepted for publication in the JOURNAL OF ECONOMIC ENTOMOLOGY shall consist essentially of original research and its application in the field of applied entomology, including quarantine activities, and other material dealing with problems of insect control.

RESOLVED, That only those papers, the publication of which is or has been specifically ordered by vote of the Publications Committee shall be exempt from the publication rules.

The Committee recommends that the names of the following persons be submitted to the Nominating Committee to serve during the year 1941: Editor, L. M. Peairs; Honorary Editor, E. P. Felt; Associate Editor, Harry B. Weiss; Business Manager, Ernest N. Cory.

F. L. CAMPBELL
A. G. RUGGLES
E. F. PHILLIPS, *Acting Chairman*

REPORT OF THE COMMITTEE ON COMMON NAMES OF INSECTS

During the calendar year 1940 your Committee has received proposals for common names to be applied to 18 different species of insects as well as proposals for changes in 6 common names previously approved. It is suggested that this list be submitted to the Association membership for vote early in 1941. At the final business session of the 1939 meetings at Columbus, Ohio, it was decided that the Committee on Common Names of Insects be authorized and instructed to present, with all proposals of new names and suggestions for changes in approved names, reasons supplied by the members of the Association making these proposals, and further that the Committee be authorized to comment wherever it might see fit to do so. Some of the proposals now on hand were received only a few days ago, and there has been no opportunity for all members of the Committee to consider them carefully and to prepare comments or recommendations where these seem warranted. This will be done immediately, and the list should be ready for reference to the Association membership early in the year.

The last comprehensive list of approved common names was published in 1937. Since then two supplementary lists, containing in all 118 new approved common names, have been published. It is recommended that the Committee be authorized to pre-

pare and publish in the JOURNAL OF ECONOMIC ENTOMOLOGY for 1941 a complete list of all the approved common names of insects including those among the proposals now on hand upon which favorable action may be taken. Members have found it inconvenient to consult supplementary lists, and it seems advisable periodically to bring together all the approved names in one paper. At the same time this gives an opportunity to make needed corrections in certain scientific names that are involved.

REPORT OF THE COMMITTEE ON CODLING MOTH FOR 1940

The work of the Committee on Codling Moth has continued much as in recent years. At the request of the Committee, the Bureau of Entomology and Plant Quarantine assembled, mimeographed, and distributed among interested workers summaries of the results obtained during the 1939 season by most of the official entomologists working on codling moth in the United States and Canada. A similar service is being arranged for the results of the 1940 season.

In the absence of an urgent demand, no conferences were held during the past year, and no conference is planned for the immediate future. The suggestion has been made, however, that perhaps by 1942 a general conference would be desirable, to review and consider the results obtained since 1938, when the last conference was held.

Under date of August 10, 1940, Mr. Paul V. McNutt, Administrator of the Federal Security Agency, announced the following increases in the tolerances for spray residues on apples and pears: Arsenic (AS_2O_3), from 0.01 to 0.025 grain per pound; lead (Pb), from 0.025 to 0.05 grain per pound. Although this liberalization of the tolerances has undoubtedly made the residue situation a little easier for growers in many regions, it is the belief of the Committee that this action has not changed the basic codling moth problem. Under present conditions, growers in many sections are having extreme difficulty in controlling the codling moth and are in urgent need of more effective methods of control. Also, a more economical solution of the problem is probably needed more now than at any previous time in recent years, since under present economic conditions, aggravated by the curtailment of export markets, the growers are facing a difficult financial situation and are finding it necessary to economize on production costs wherever they possibly can. In many areas the cost of codling moth control is one of the largest of the items that make up the cost of production. The Committee therefore feels that all research under way on the codling moth should be continued, and even intensified if possible.

C. R. CUTRIGHT
W. A. ROSS
W. S. HOUGH
JAMES MARSHALL
B. F. DRIGGERS
B. A. PORTER, *Chairman*

REPORT OF THE COMMITTEE ON INSECTICIDE TERMINOLOGY

Your Committee on Insecticide Terminology which has in the two preceding years made very definite recommendations for the guidance of the Editor of the JOURNAL OF ECONOMIC ENTOMOLOGY has found it necessary to consider the purpose and functions for which it was created. These have not heretofore been definitely specified.

Purpose

We consider it the purpose of this Committee to promote uniformity of Terminology in the field of chemical and physical control of insects. It is intended that recommendations of this Committee that may be approved by the Association shall be followed by the contributors to the JOURNAL OF ECONOMIC ENTOMOLOGY.

Functions

We consider it the functions of the Committee:

1. To accept, consider and act upon appropriate suggestions of any member of the Association.
2. To initiate the study of such topics as the Committee feels need attention and to report to the Association through the Executive Committee the results of such studies.
3. To collaborate with committees similar to our own in societies representing allied sciences in order to secure the desired uniformity of terminology.

The Committee plans to prepare a list of approved abbreviations of units of measurement, the use of which in the tables and text of contributions will conserve space in the JOURNAL.

The Committee also is planning an approved list of the names (and synonyms) of compounds used as insecticides or in combination with insecticides.

Respectfully submitted:
C. M. SMITH
R. H. ROBINSON
F. L. CAMPBELL
W. R. HORSFALL
HARRY F. DIETZ, *Chairman*

REPORT OF THE COMMITTEE ON POPULAR ENTOMOLOGICAL EDUCATION

Entomology in 1940 had to compete with the Blitzkrieg, the Third Term and National Defense for space in the press and for time on the radio. Save for the story issued by the Germans that the British were spreading potato beetles in the Reich, which made the front pages of newspapers through the country and most radio newscasts, few sensational insect stories developed during the year.

Entomology departments, extension workers, the U. S. Bureau of Entomology and Plant Quarantine, and the various commercial concerns continued to turn out their usual volume of popular entomological material, much of which received mass coverage through the press, radio, movies, and exhibits.

Your committee, in addition to encouraging all entomological agencies to step up their publicity efforts in 1940, has concentrated on getting editors and feature writers of magazines with more than a million circulation interested in insect damage and what entomologists are doing to avert it. A letter summarizing the insect problem and accompanied by Hyslop's "Losses Occasioned by Insects, Mites and Ticks in the United States" was sent to each magazine editor in the United States. An offer to supply further information and photographs was made. All expressed interest and many of the larger publications have since carried articles on insects.

Insects and National Defense has a popular appeal at the present time, but few concrete stories are available.

In view of the enormous effort now being put forth by all agencies to receive favorable publicity on their work, your committee recommends that our Association redouble its public relations work in 1941. To that end each member is urged to put forth more individual effort on publicity and that copies of all papers scheduled for next year's annual meeting be submitted to the Secretary well in advance of the convention date.

Respectfully submitted,[1]
J. A. HYSLOP
T. H. PARKS
P. D. SANDERS, *Chairman*

COMMITTEE ON COOPERATION WITH PEST CONTROL OPERATORS

Your committee on Cooperation with the National Pest Control Association, having met with the committee of that Association and discussed at length the problems of mutual interest, begs leave to report as follows:

1. *Legislation.* We commend the National Pest Control Association in its efforts to regulate and standardize, within the industry, the service operations of the commercial pest control operators, as evidenced by the activities and reports of its committees dealing with Fumigation Practices and Termite Standards and Procedures.

In considering state legislation which may become necessary we propose and recommend cooperation with the pest control industry in the drafting of such basic principles as might comprise a fundamentally acceptable law.

2. *Literature.* Because of the lack of research in the field of household pests, many state and federal publications, for distribution to the public, contain information wholly out of date and in some cases with incorrect statements. Furthermore, there is a wide diversity of recommendations in different publications. Therefore, it is suggested that those preparing such publications make a more thorough comparison between laboratory findings and commercial experiences, to the end that more uniform recommendations be made.

It is also believed that such publications should recognize the services of pest control operators as has been done in some state and federal bulletins. This is especially important in the case of structural fumigation.

3. *Research.* We would like to repeat a statement made in our last report, to the effect that entomologists should become better acquainted with commercial operators, as well as familiarize themselves with the problems and needs of such operators, to the end that they may realize the vast field of applied entomology which has been greatly neglected and that they may make greater efforts to enlarge their investigations of household pests.

The amounts of financial aid from state and federal sources are wholly inadequate to carry on the much needed research in this phase of entomology and special efforts should be made to secure adequate funds. We recommend, therefore, that this association indorse the present program of the National Pest Control Association petitioning for greater federal funds and urges their assistance in cooperative endeavors that will make for further appropriations in the various states.

[1] R. R. Reppert, deceased, 1940, was a member of this committee.

4. *Common Names.* We commend the initiative of the National Pest Control Association in submitting to its members a list of common names of household insects prepared by Dr. F. L. Campbell, which included the list approved by our association and the names used by various authors. This list and reactions by members of the industry will be published in the January 1941 issue of pests magazine and should be studied by members of our association. Furthermore, it is recommended that common names, especially those within the field of commercial pest control, being considered by our Committee of Common Names, be submitted to members of the National Pest Control Association, for comments, in the eventual selection of common names of insects.

Respectfully submitted,
AVERY S. HOYT
W. P. FLINT
J. J. DAVIS, *Chairman*

THE COMMITTEE ON THE RELATION OF ENTOMOLOGY TO CONSERVATION

Many conservation problems are closely bound up with National Defense, and entomology takes an important place in conservation. Insects play a prominent role in connection with the conservation of our forests, soils, buildings, clothing, foods, health, happiness, and the esthetic values of life. Therefore it is imperative, especially under existing world conditions, to include entomology in every conservation program.

The question naturally arises as to how this may be accomplished. Certainly there has been a lack of general appreciation of the importance of insects as factors in conservation work. Probably this is partially if not largely the fault of entomologists. Much of the damage caused by insects is not generally obvious, and the intricate relations between agricultural practices and insect damage is often obscure.

In the opinion of this committee there is need for closer cooperation between entomologists throughout the country and those engaged in other aspects of conservation. Much of the forest, soil and water conservation work is decentralized, and the entomological and other factors often vary widely in different regions or even localities. Therefore, the active participation of those entomologists possessing an intimate knowledge of local problems and practices in the planning and execution of land use and other conservation programs is most desirable and necessary. The entomologists should not be put in the position of being compelled to solve insect problems that may be produced or intensified by certain practices recommended in a conservation program without having an opportunity to aid in the planning of the program or in watching its development.

It is certainly true that entomological problems are now being given more consideration and entomologists are being called upon to participate in conservation work more often than a few years ago. This recognition of the importance of insects and the cooperation of various agencies can be fostered all entomologists would familiarize themselves with conservation programs involving their work territory, and actively participate in the planning of those programs. It seems doubtful if entomologists will make rapid progress in this cooperative undertaking if they simply ask a conservation group if entomological help is desired. Such a group often does not know about existing insect problems or how

changing agricultural practices may influence insect depredations. The entomologists must show the necessity of considering insect problems and ability to help solve them.

Cases in which insect problems have been included in broad conservation undertakings are by no means lacking, and these should encourage the inclusion of entomology in all such programs.

Previous reports of this committee have pointed out some of the fields in which research is urgently needed. We desire to again emphasize the importance of gaining satisfactory answers to the many entomological questions which have arisen, or are likely to arise in the development of conservation programs.

The committee is planning to assemble information on research projects having a definite bearing on conservation, with a view to exchanging information, securing coordination, and also in aiding in the protection of long-time conservation projects against undue interruption by defense problems. The committee also feels that it might act as a clearing-house for information as to important problems needing investigation, places and facilities for the prosecution of such studies, and personnel available.

The committee recommends its continuance and appeals to entomologists of the country to submit suggestions as to how the committee and Entomology as a science may become most useful in furthering all aspects of conservation in America.

T. H. FRISON
H. L. SEAMANS
F. C. BISHOPP, *Chairman*

REPORT OF THE COMMITTEE ON ADVANCEMENT OF OFFICIAL ENTOMOLOGY

The business of this committee is to keep a constant watch on the field of official entomology for the purpose of anticipating the needs and opportunities for official entomology as the trends appear.

The outbreak of the second World War has created a situation very similar to that brought into being by the outbreak of the last World War. The male citizenry of this country between the ages of 21 and 35 inclusive has been registered for defense service and the question of whether entomologists can best serve their ountry through defense employment along the lines of their specialized training has arisen. At the present time both public and official opinion are in agreement that they will be most useful along lines of their special training. With this idea in mind the National Resources Planning Board and the United States Civil Service Commission are developing a roster of scientific and specialized personnel for the purpose of providing a comprehensive list of highly trained Americans possessing special abilities in their respective fields. Two questionnaires, one of a general nature and the other of a special nature, the latter including entomology, are being circulated co-incidently.

It is recommended by your committee that this action on the part of the National Resources Planning Board and the United States Civil Service Commission be given unqualified approval by the membership of the two entomological societies.

Mr. E. R. Sasscer in his Presidential Address, which was published February, 1940 in No. 1, Volume 33 of the JOURNAL OF ECONOMIC ENTOMOLOGY, after reviewing invasions and attempted invasions of the United States by foreign insects, proposed a three-fold plan of defense. According to Sasscer, the first line should consist of a group of scout entomologists who should investigate and gather data concerning the prospective invaders in those parts of the world in which they are at present active. The second line of defense should be located at the ports of entry of the United States where a group is engaged in the prevention of successful debarkation of the invaders. The third line of defense consists of official and prviate entomologists practicing their profession in the employ of industry, Federal governments and the States. Sasscer was apparently led to make this proposal by his intimate study of the problems of insect control in the country in general and specifically by his intimate connection with and knowledge of the problems as they appear in the second line of defense.

In his address Mr. Sasscer placed his finger on the all important point in insect control in the United States in these words: "To be effective this threefold defense should have behind it the full power and purpose of the people." The point that your committee wishes to bring before you is clearly set up in this quotation. The problem is how to get the full power and purpose of the people behind an adequate program. Your committee knows no better way of accomplishing this result than public education in these matters. Public education assumes many forms, such as newspaper articles, magazine stories, public lectures and last, but not least, dramatically written, interesting books. Of all these agencies the popular written book or books is probably in the long run by far the most effective. It is the most effective because it has continuing action. Newspaper articles, public addresses and magazine stories are soon forgotten but the reader comes back time and again to the good, well written and well distributed book or books. Your committee believes that the book or books needed for this job are not primarily technical but popular. The numerous economic and general entomology books with which our shelves are lined are not suitable for this purpose. Such a book as Dr. Howard's "Insect Menace" more nearly approaches the needs of the case.

Your committee, therefore, wishes to recommend that the two entomological societies endorse an effort of this kind and place this responsibility in the hands of an appropriate committee.

FRANK N. WALLACE
THOMAS J. HEADLEE
GEORGE A. DEAN, *Chairman*

REPORT OF THE REPRESENTATIVES ON THE COUNCIL OF THE UNION OF AMERICAN BIOLOGICAL SOCIETIES

Your representatives on the Council of the Union of American Biological Societies were both newly elected at the last annual meeting, and much of our effort during the past year has been to familiarize ourselves with the background and work of the Union.

This organization consists of a federation of those scientific societies which are interested in biological subject matter. The Union appears to have been established in the first instance in order to provide a forum at which various problems common to the different biological societies could be discussed, with the expectation that in certain instances harmonious and united action would be desirable.

During recent years the work of the Union has been confined entirely to two subjects: the sponsorship of the publication of *Biological Abstracts*, and

the development and support of a comparatively new organization known as the National Association of Biology Teachers. The Union has energetically attempted to enroll greater numbers of high school teachers in this latter organization and has made a survey of the equipment needs of these teachers. This work is made possible by a 3-year grant from the Carnegie Fund for the Advancement of Teaching, and the work is progressing satisfactorily. This feature of the Union's activities is under the chairmanship of Dr. Oscar Riddle.

By far the most important work of the Union consists of its relationship to *Biological Abstracts*. It is well recognized both by the Board of Trustees of the *Abstracts* and by the officers of the Union of Biological Societies that this publication does not fill nearly as important a need in the case of entomologists as it does in several other biological fields, particularly botany and bacteriology. This point of view has been vigorously emphasized both by the previous and the present representatives of the entomological organizations in the Union of Biological Societies. As the result of last year's report of special committees appointed by this organization and by the Entomological Society of America, consideration was even given by the editors to discontinuing entomological abstracts in this publication. Entomologists feel, apparently unanimously, that the field of economic entomology is more adequately covered by the *Review of Applied Entomology* and that the field of taxonomy is covered by the *Zoological Record*, and it is desired to continue to support these publications rather than to weaken them by transferring our subscriptions to the more recently established *Biological Abstracts*.

On consideration of this subject, however, the Board of Trustees decided that the abstracting of entomological literature was important to biologists other than professional entomologists and should therefore be continued in order to make the literature relating to insects more readily available to botanists, zoologists, bacteriologists, and other biological workers, and that policy is being continued.

The present war, by eliminating European subscriptions, has made the maintenance of *Biological Abstracts* increasingly difficult, but we are pleased to report that the financial problems for 1940 were successfully solved, at least for the present, and that the continuance of *Biological Abstracts* throughout at least the calendar year 1941 is assured. The publication has a meager financial reserve which it was necessary to tap to the extent of less than 3 per cent of its $45,000 budget for this year. The new business manager has succeeded in obtaining in this country, since last July, 75 new subscriptions for the complete edition and 150 for sections. Meanwhile the editors have been able to provide for the publication of the index volumes which were badly in arrears several years ago, and these volumes are, we believe, now up to date.

For the convenience of subscribers, *Biological Abstracts* is now issued in the form of five separates as follows: (a) General Biology; (b) Experimental Animal Biology; (c) Microbiology, Immunology, and Parasitology; (d) Plant Sciences; and (e) Animal Sciences. The subscription price has been reduced and the section on Animal Sciences can now be obtained by individual subscribers for $5.00 a year.

Your representatives on the Union of American Biological Societies have been in touch personally and by correspondence both with the officers of the Union and with the Editor of *Biological Abstracts* during the past year, and feel that, from the standpoint of the self-sacrificing effort which is being given to *Biological Abstracts* and the improvement in coverage, the present management is to be congratulated. During the year 1939 the coverage of journals increased from 895 to 1175, and in 1940 it has further increased to 1345 journals. A total of 18,108 abstracts were printed in 1939 and this represented an increase of almost 11 per cent over the preceding year; about 17,000 are being published in 1940.

The efforts to publish abstracts more promptly than previously have also been gratifyingly successful. In October 1936, only 24 per cent of the abstracts of that number were from current year's publications; while, in October 1939, 82 per cent of all abstracts were from papers published in 1939.

Your representatives suggest to the members of the American Association of Economic Entomologists that from several standpoints their individual support of *Biological Abstracts* is desirable and well worth while:

1. It is the only publication in which brief reviews of the large mass of related botanical and physiological literature can be obtained, much of which provides a background for entomological work.

2. It provides an established organ which can take over temporarily, if necessary, the more complete coverage of the *Review of Applied Entomology* and the *Zoological Record*, in the event that the publication of these British journals is interrupted on account of war conditions.

3. It provides a way in which the subject matter of papers relating to insect life may be made available to biological workers in other fields.

On the other hand, so long as the *Review of Applied Entomology* and *Zoological Record* remain in the field, your representatives do not suggest a change in the present policy of continuing our primary support of these publications.

In view of the fact that a skeleton organization such as the Union of American Biological Societies serves a useful purpose not only in the sponsoring of *Biological Abstracts* but in being available for such other activities as sponsoring the recent organization of biology teachers, a small contribution to aid the clerical work of the Union might appropriately be considered by the Executive Committee of this Association.

S. B. FRACKER
W. J. SCHOENE

REPORT OF THE REPRESENTATIVE ON THE NATIONAL RESEARCH COUNCIL

A few words as to the organization of the National Research Council may not be out of place in that persons not closely associated with it usually have only a vague conception of the plan of organization.

Briefly, the National Research Council is a cooperative organization of the scientific men of America. Its members include scientific and technical men, and business men interested in engineering and industry. The National Research Council was established in 1916 by the National Academy of Sciences and is supported by the cooperation of the principal scientific and technical societies of the country. The actual membership of the Council is composed largely of representatives of over 80 societies including representatives of Government scientific bureaus and a limited number of members

at large numbering in all about 220. The present chairman of the National Research Council is Ross G. Harrison, Sterling Professor of Biology and Director of Osborn Zoological Laboratory, Yale University.

In addition to a rather large number of standing committees and representatives of various branches of the Federal Government which report directly to the Executive Board, the work of the Council is divided into two groups: one having to do with General Relations consists of two divisions, the Division of Foreign Relations and the Division of Educational Relations. The other group, and by far the larger, consists of the Divisions of Science and Technology, of which there are seven divisions. With the two divisions under General Relations there are nine main divisions in all.

The division with which the American Association of Economic Entomologists is principally concerned is the Division of Biology and Agriculture, of which Prof. Robert F. Griggs, George Washington University, was elected chairman at the last annual meeting succeeding Dr. R. E. Coker, who served as chairman for several terms. This division in turn is subdivided into eight groups, of which group VIII is composed of representatives of the following organizations: American Association of Economic Entomologists, Entomological Society of America, American Society of Mammalogists, and American Society of Parasitologists.

The work of the division can be summarized by mentioning the character or status of the reports submitted by the various committees, some of which are interdivisional.

The last meeting of the Executive Committee, of which Mr. S. A. Rohwer, as a representative of the American Association of Economic Entomologists, was a member, voted to recommend a reorganization of the Division by dropping the group system of representation now in effect and selecting members of the Executive Committee by vote of the Division itself upon nomination by the Executive Committee. There were three principal reasons for the change:

(1) Some societies, for example, the Society of Mammalogists, who had been placed in group VIII along with the Entomologists and Parasitologists, did not feel that they had been properly allocated, that they were in the wrong group, but it was impossible to change them under the old system.

(2) At the last annual meeting, the American Institute of Nutrition was, by vote of the Division, invited to join the Division and was later added to group VII, making five members in that group. This would mean that any one of the five member societies would have a member on the Executive Committee only once in 15 years, which is altogether too long a period. Further such situations would increase in the future if the Division grows as it should.

(3) Under the present arrangement, distinctions are drawn among the elected representatives of the member societies. Some are active members while others are merely "advisory representatives" without the right to vote. The recommended reorganization puts the representatives of all the constituent societies on the same footing in every respect except that since the Council does not have funds sufficient to pay the expenses of all members attending the meetings, "Executive Members" will be selected as before. This flexibility will permit the Executive Committee to take into account such factors as the geographic location of the members so as to accomplish the utmost with limited resources.

The Committee on Aerobiology, which is an interdivisional committee, has reported two projects, the first of which should be of particular interest to entomologists:

(1) The Subcommittee on Apparatus has submitted for publication in Phytopathology a paper entitled "Techniques for Appraising Air-Borne Populations of Microorganisms, Pollens, and Insects."

(1) A symposium on "Problems of Aerobiology" is scheduled for the next summer meetings of the American Association for the Advancement of Science.

The Committee on Biological Processes of Aging. The Surgeon General of the United States Public Health Service has requested the continuance of this committee that it may work in close cooperation with the Committee on Gerontology of the Public Health Service. The Council's committee will be primarily concerned with fundamental problems in aging while that of the Public Health Service will be concerned with the more practical aspects of the subject.

The Committee on Forestry. The bibliography on forestry which was mentioned in last year's report has been published by the U. S. Department of Agriculture as "Bibliography of North American Forestry," Miscellaneous Publication No. 364, pp. 1–1142. The bibliography includes the more important references published in Canada, Mexico, and in the United States prior to 1930. A general forestry seed manual is in preparation by the committee and a book on forest tree seed is being made ready for publication by a member of the committee.

The Committee on Research Publications.—The committee in cooperation with publishers and editors of biological journals is studying the possibilities of bringing about greater economy in publication without sacrifice of quality and with the possibilities of increasing volume of publication at given expense, and what should be of interest to all who write or edit papers, a manual is in preparation of information on printing problems for editors.

The Committee on Food and Nutrition.—The Council on National Defense has requested the National Research Council, which request was seconded by the Department of Agriculture, to appoint a committee on the scientific aspects of nutrition. In response to this request a committee on food and nutrition was set up under the Division of Biology and Agriculture, Division of Medical Sciences, and the Division of Anthropology and Psychology to be administered by the first named. The government has asked that the committee recommend standards for diets necessary to secure proper nutrition. It is anticipated that this committee will play an important part in connection with the national preparedness program.

Barro Colorado Biological Reserve.—On July 2 President Roosevelt signed the law setting aside Barro Colorado Island in Panama for a Biological Reserve. The Board of Directors consists of the Secretary of War, Secretary of the Interior, Secretary of Agriculture, Secretary of the Smithsonian Institution, President of the National Academy of Sciences, and three eminent biologists to be designated by the last named. The appointed members are Thomas Barbour, Executive Officer, Elmer D. Merrill, and Alexander Wetmore.

The Committee on Ecology of Grasslands has continued their activity and at the request of the Department of the Interior prepared a special report regarding the proposal to establish a grasslands national monument in Northwestern Nebraska and

Southwestern South Dakota. Entomologists interested in this report and other work of the committee can secure information from the Division or the chairman of the committee, Dr. Paul B. Sears.

Committee on Pharmacognosy and Pharmaceutical Botany.—Work has been continued in promotion of a survey of the wild native medicinal plants. Data respecting Georgia and Oregon surveys have been published in mimeographed form. Surveys in Ohio, Massachusetts, and Michigan are in progress, and promises of cooperation have been received from South Carolina, Wisconsin, and West Virginia. The Committee has held discussions with members of the U. S. Department of Agriculture regarding dwindling imports of certain drug plants looking toward greater independence of foregin sources subject to loss in times of emergency.

C. E. PALM
JAS. I. HAMBLETON

REPORT OF THE CROP PROTECTION INSTITUTE

In 1940 the Institute has conducted research work similar to that of prior years. The work has had a tendency to be more concentrated than in other years. There has been more extensive effort within a project but smaller number of projects.

As yet the growing emphasis on production of defense materials is not substantially reflected in Institute projects. However, the Institute feels the uncertainty in the minds of large business organizations as to what they can safely undertake in the way of expansion. No company can properly expand into new lines or products, or make substantial increases in existing lines, unless it can see its way clear, not only to finding a market for those products but to amortizing the cost of new equipment within a reasonable space of time.

The following is a summary of the Institute's investigational work for the year 1940.

1) *Carbide and Carbon Chemical Corporation—Organic Fungicides.*—Dr. R. H. Wellman continues his resourceful work at the Boyce Thompson Institute, with the collaboration of Dr. McCallan. This project and the one that follows were expanded beginning with January of this year. Attention was about equally divided between the study of organic fungicides and the study of organic insecticides described in the next section. The company also provides able work in its research laboratories, in the synthesizing of new materials.

Approximately 300 compounds have been under study in the fungicide studies. Four species of spores are used. Bordeaux mixture provides the base line. Of the various compounds so far studied ten are more toxic than copper sulphate. Two of these have already been reported on elsewhere, but eight are new. The slope of toxicity curves of these new materials in relatively steep.

The most toxic chemicals do not show adequate tenacity. However, satisfactory adhesions have been attained with the use of a sticker prepared in the company's laboratory. The compounds are relatively stable to ultraviolet light. Phytocidal tests indicate a highly encouraging margin of safety in the case of several of the more toxic materials. Additional studies in this project include tests as weed killers.

In the course of the year this project contributed to fundamental studies of methods in laboratory testing. One paper on this aspect has been prepared for publication and two abstracts are scheduled.

The work is yielding some data which begin to shed light on the relation of chemical constitution to toxicity. It is too early yet to make any broad generalizations, but certain fundamental aspects are becoming fairly evident.

2) *Carbide and Carbon Chemical Corporation—Organic Insecticides.*—Dr. E. N. Woodbury continues his work on this project under the direction of Prof. Davis, at Purdue. Both this project and the preceding one are under the technical supervision of a committee including Dr. McCallan, Dr. Thurston, Dr. O'Kane, Prof. Davis, and Dr. Horsfall.

In general, the organic compounds studied as to fungicidal activity are available also for investigations as to their insecticidal possibilities. In the insecticidal aspects studies have been confined to possible contact insecticides and fumigants until the last three months, when repellents have been added.

Approximately 80 compounds have been given a standard test against *Aphis rumicis.* More recently a group of compounds has been discovered which shows a high toxicity against insects and which seem to offer promise for more intensive investigation. Here, as with the fungicidal studies, fundamental aspects are receiving attention and some generalizations relating to chemical structure are beginning to take form.

3) *General Chemical Company.*—Several lines of investigation have continued, following work already initiated in 1939 or earlier.

The compound xanthone, which General Chemical Company has developed under the name *Genicide*, was given additional tests on codling moth through cooperative arrangements made by the Institute with the Missouri Experiment Station, the Oklahoma Experiment Station, and an Iowa fruit grower, Robert H. Clark, who works closely with the Iowa station. Full data are not yet available. The results in Oklahoma however are complete and exhibit better control with *Genicide* as a second brood spray than was exhibited by the standard lead arsenate schedule. Further work with *Genicide* was carried out in Missouri in control of oriental fruit moth.

A combination of stomach poisons was tested in substantial field blocks for boll weevil on Sea Island cotton through a cooperative arrangement made by the Institute with the Georgia Department of Agriculture.

In North Carolina various combinations of sulphur and copper in dust form were applied for control of leaf spot and leaf hoppers on peanuts and for control of downy mildew on cantaloupes. Also field blocks were set up testing the relative merits of two types of gypsum as applications on soil in the growing of peanuts. In Louisiana, copper compounds were compared in the control of strawberry leaf blight and as applications on peppers.

Various exploratory studies were carried out for this company in 1940. A series of cattle sprays were examined by means of the new insect toxometer developed at the University of New Hampshire and accurate information was obtained on the value of constituents of the sprays. A similar series of plant sprays was studied in the same way. A series of basic lead arsenates was investigated through cooperation with Ohio State University. A similar series of acid lead arsenates is now under study. A group of poly sulphides was given preliminary examination through cooperation established with the Boyce Thompson Institute.

4) *Rohm & Haas Company.*—Intensive studies of cuprous oxides continued through 1940, under the

supervision of Dr. Horsfall and with Dr. J. W. Heuberger as the investigator. Beginning in the summer of 1940 as assistant was provided for the purpose of investigating organic fungicides.

In the work with cuprous oxides a new technique was developed for laboratory determinations of tenacity and toxicity after weathering. Among the insoluble coppers cuprous oxides proved to have the highest tenacity, approaching that of bordeaux. Another new technique included designing of a settling tower for studies of dusts. The tower is giving reproducible results. Also, it is disclosing some unsuspected factors in the settling of compounded dusts.

Yellow cuprous oxide continued to give the highest plant disease control among the insoluble coppers in extensive experiments on tomatoes. Work on a large scale yielded important data on the timing of tomato spraying for *Altenaria*. Dosage studies showed optimum gallonage. A spray schedule for celery was investigated.

Data were accumulated showing the relation of hail injury and frost injury on melons to the effect of some sprays and dusts on the foliage.

Among organic fungicides a compound was discovered which gave complete control of powdery mildew on roses, where other fungicides did not give control. This same compound gave complete control of powdery mildew on squash. Another compound gave good control of black spot on roses.

5) *United States Rubber Company—Fungicides.*—This project, along with the one described in the next section, continued through 1940. Dr. Albert E. Dimond was employed as investigator with the assistance of Mr. George E. O'Brien through the major part of the year.

In addition to compounds submitted before the current year, 69 new materials were investigated. The total number of compounds studied to date is 468. Bordeaux coefficients were determined for the more promising of these, including 34 materials. Also, tenacity coefficients were determined.

One material, No. 120, already extensively studied, gave excellent protection against pre-emergence damping-off of lima beans. Two types of results were recorded: (a) increased emergence of the treated as compared with untreated seeds and (b) increased fresh weight of treated plants. Another material, No. 297, gave good control of apple scab in a year of heavy scab infection. Two organic compounds gave good control of cedar apple rust.

6) *United States Rubber Company—Insecticides.*—Seven lines of experimentation were undertaken. Indicative results of 1939 were retested and improvements developed. Large-scale field tests were made in Florida, New Jersey, and New England. The purpose and scope of each study follows:

Fumigants. Materials found to possess fumigation properties in 1939 were again tested. Six proved moderately promising.

Rodent repellents. Materials which had displayed value as rodent repellents in exploratory tests were incorporated in wrapping paper and rubber sheeting. Nineteen were tested and eight were found promising.

Contact insecticides. Initial tests were run on new materials, and those having definite promise were incorporated in insecticide emulsions. Developmental work produced an excellent insecticide emulsion, No. 209. The company placed this on the market under the name *Syntone*. It was given large-scale field tests in Florida on garden crops and citrus fruits; in New Jersey and New England on potato, fruit, and tobacco crops.

Mothproofing. Initial tests of new materials, monthly checks of previously tested chemicals, large-scale tests of suits and sweaters treated with newly-developed mothproofing agents, and the subjection of treated cloth to weathering, dry-cleaning, and laundering, provided a variety of studies. Ninety-six materials were examined.

Stomach poisons and repellents. Exploratory tests were run on fifty-eight new materials as possible stomach poisons or repellents.

Ovicides. Several materials which are solvents for derris resin are being tested for toxic action on insect eggs.

Fungicide compatibility. Seven new materials were tested as to compatibility with *Syntone* under field conditions.

Robert J. Norton was employed until April 30, when he was taken over by the supporting company. Almon M. Lord was employed until September 30, at which time he was taken over by the supporting company. Stuart D. Edmond was employed until the close of 1940.

7) *Mathieson Alkali Works, Inc.—Organic Fungicides.*—Beginning in the fall of 1940 a preliminary project was set up with the Mathieson Alkali Works, for initial study of a series of organic compounds originated in the company's research laboratories. Fungicidal studies were placed under the direction of Dr. McCallan at Boyce Thompson Institute. Insecticidal studies were under the direction of the writer. Thirty-three materials were submitted.

Initial tests as to toxicity to spores indicated that thirteen of these compounds were entitled to further investigation. Six of the more toxic compounds were tested in the greenhouse for foliage injury. Three of them gave no injury.

Insecticidal tests of the same series of compounds disclosed toxicity to *Aphis rumicis* in six materials.

8) *Research Corporation.*—Utilizing a fund which had remained on deposit with the Institute, a temporary project was set up to accumulate facts as to the insect toxicity of a plant which grows in various parts of the United States. The toxicities exhibited by various samples were not of a high order but seemed to indicate the possibility that plant breeding may yield improved strains of definite value to the American farmer and fruit grower.

W. C. O'KANE

REPORT OF THE COUNCILORS FOR THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

The meeting of the council was confined largely to routine matters. There were 410 members representing about 10 special fields of science elected as fellows of the association. This list did not include any names from Section F because none had been received from the section secretary up to the time of the meeting of the council. It was decided that such names could be included if submitted subsequently.

A motion was passed directing the incoming President, on advice of the incoming executive committee, to appoint a committee to study the problems of the journals of the association including the existing contract and the whole policy of the publication of the said journals.

Dr. J. W. Buchanan, Northwestern University, was elected secretary of Section F for 4 years and Dr. Irving Langmuir was elected President of the Association for the ensuing year.

W. S. HOUGH
C. P. CLAUSEN

REPORT OF THE TRUSTEE OF THE TROPICAL PLANT RESEARCH FOUNDATION

There is little to report in addition to what was given in the report of last year. The Foundation has had no new projects to consider and no requests looking to required action in the near future. Under present conditions we can hardly expect opportunities to inaugurate new projects in this field of investigation. The funds of the Foundation are held as heretofore and, except for depreciation of values from world conditions, may be counted as of about the same value as stated in last year's report. Dr. Crocker, as Acting Director, is giving careful attention to the affairs of the foundation, and deserves much credit for his service which is without financial compensation. The Foundation may be considered as still alive, and its facilities available for collaboration with any organization interested in its scope of Tropical Research.

As the normal term of four years of your representative on the Board has expired, it will be in order to nominate a successor for election by the board, this being the ordinary procedure for appointment of members of the board. I will be pleased to report any nomination from the society to the President of the Board for action by its members.

Respectfully submitted,
HERBERT OSBORN

REPORT OF THE COMMITTEE ON INTER-AMERICAN CONGRESS

It was the sense of the committee that the proposed Inter-American Congress of Entomology suggested by the Eastern Branch of the American Association of Economic Entomologists possesses merit if properly organized and conducted. It is a subject, however, which deserves more consideration and study than has been possible in the limited time which could be given by the committee. Such being the case, it is the recommendation of the committee that the subject be further explored and that the President appoint at a reasonably early date another committee to study the proposal and report back to the Executive Committee at the next annual meeting.

E. R. SASSCER
MORTIMER D. LEONARD

REPORT OF THE COMMITTEE ON THE ESTABLISHMENT OF LOAN SCHOLARSHIPS

Informal consideration has been given to the desirability of the American Association of Economic Entomologists establishing one or more loan scholarships for the purpose of fulfilling in a greater manner one of our two objectives, namely to promote the study of entomology. Such scholarships if properly assigned would unquestionably result in a forced evolution of capable men who may be impeded in their proper development by economic conditions.

Such an effort upon the part of our Association seems highly desirable, and it is hereby recommended that the Association authorize the continued study of this matter with the objective of having a formal report made at the 1941 meetings on ways and means by which such an activity might be effectively engaged in.

JOHN T. CREIGHTON

EIGHTH AMERICAN SCIENCE CONGRESS

The eighth American Science Congress was held in Washington, D. C., May 10 to 21, 1940. Extended programs were presented under eleven sections, three of which pertained to subjects dealing with or relating to economic entomology. These were Biological Sciences, Agriculture and Conservation, and Public Health and Medicine.

No economic entomologists from South and Central America were present at the sessions on Biological Sciences, and only three papers were listed in this and other sections dealing with economic entomology. These papers were presented by title only.

The section on Agriculture and Conservation was well attended, and an extensive series of papers presented on the broader aspects of the problems of conservation.

In the section on Public Health and Medicine, one session in two sections was devoted to the presentation of papers dealing with yellow fever, malaria, and various other insect-borne diseases.

Arrangements for the handling and conduct of the Congress were excellent. Of particular value was the installation and use of the Filene-Findlay Speech Translation System. An extensive program of entertainment was provided for the delegates throughout the ten days the Congress was in session.

E. N. CORY
F. C. BISHOPP
C. P. CLAUSEN, *Chairman*

SPECIAL COMMITTEE ON RESEARCH MONOGRAPHS

A Committee on Research Monographs was appointed by President Smith on October 4 to consider the subject of research monographs in entomology, with particular reference to a communication received by the Association from the Committee on Research Monographs of the Association of Land-Grant Colleges and Universities. The committee of the Association of Land-Grant Colleges and Universities has been in existence for some time and has been attempting to stimulate the production of research monographs "to assemble, organize, condense, and evaluate available information on the more important subjects of agricultural research so that new researches may be planned on the basis of a comprehensive knowledge of previous work." Your committee has interpreted its instructions as broad enough to enable it to consider the general subject of research monographs in entomology, both as it relates to the work of the committee of the Association of Land-Grant Colleges and Universities and to the interests of the Association of Economic Entomologists itself.

It is the opinion of the committee of the Association of Land-Grant Colleges and Universities that the monographs should be on subjects that require fundamental research and that are of widespread interest, and before any monograph is undertaken that the counsel and cooperation of interested agencies should be sought. To this end the committee wrote to the American Association of Economic Entomologists to supplement the data it had already gathered and is asking an expression of judgment from the Association of Economic Entomologists and from various other national scientific societies on three points, viz.: subjects in its field that are in the greatest need of such review, outstanding authorities who might be invited to prepare the monographs, and practicable means of publications.

It is the judgment of the committee of the Association of Land-Grant Colleges and Universities that the monographs be made possible through the cooperation of interested agencies, such as the United States Department of Agriculture, the State Agricultural Experiment Station, scientific journals, commercial publishing houses, and by the sale of monographs. No funds are available to the Association of Land-Grant Colleges and Universities for the publication of monographs, and the function of its committee as expressed by it is "to cooperate with the Office of Experiment Stations in promoting and authorizing the monographs—not to publish them."

Your committee has discussed this subject with members of the committee of the Association of Land-Grant Colleges and Universities and with the Chief of the Office of Experiment Stations who has cooperated closely for the last two or three years in the work of that committee. It appears from information available that the Association of Land-Grant Colleges and Universities is in a position to assist in finding avenues for publication of monographs considered appropriate by it and to assist in obtaining release of competent men in the Department of Agriculture and in the State Experiment Stations from some of their other duties to permit the production of monographs when the subjects and authors are approved by it. However, avenues of publication are scarce and it is indicated that projects by any of the scientific societies looking toward the publication of monographic reviews and critical evaluations of research would be encouraged and that publication by them would help solve some of the present difficulties in finding avenues for the presentation to the public of such work.

The need for critical reviews in entomology was discussed at the meetings of the North Central States Entomologists at Purdue in March, and a resolution was adopted to the effect that the chairman of that conference direct the attention of the Executive Committee of the American Association of Economic Entomologists to the need for comprehensive reviews of specific phases of entomology. The need for comprehensive, critical reviews in restricted entomological fields has been discussed with various entomologists by members of your committee and there seems to be a general opinion, in which the committee concurs, that the publication of such reviews, summarizing and evaluating the status of research in restricted fields, prepared by men recognized as competent in the field treated, is badly needed in the increasingly complex field of entomological research. After review of the situation, your committee is of the opinion that much more rapid progress can be made in obtaining such critical evaluation of various research fields in entomology if the Association of Economic Entomologists will attempt to provide its own means for periodical publication of carefully selected critical reviews of a comprehensive nature, rather than to depend entirely on action which may be forthcoming from the committee of the Association of Land-Grant Colleges and Universities. That association, through its committee, may be in a position to help with the administrative details of releasing men from other duties for the purpose of making such reviews if this is necessary; full advantage should be taken of such assistance.

Reviews such as the committee visualizes would be restricted in scope so that the subject could be treated adequately in the space available. The treatment should not be bibliographic in nature, although thorough knowledge of the literature would be necessary; rather it should be based on a review of the present status of research in the field selected and should present a careful, critical evaluation of the work done and an appraisal of our present knowledge of the field, in which the gaps in research information would be revealed and the well-established facts indicated. As an example of the type of review the committee has in mind, Uvarov's "Insect Nutrition and Metabolism" or his "Insects and Climate" are cited.

In order to provide for effective consideration of this problem your committee recommends:

(1) That the Executive Committee go on record as favoring the publication of at least one review supplement to the JOURNAL, presenting a critical review of the status of research in a restricted entomological field provided such a project can be financed adequately by the Association;

(2) That in order to familiarize the Association with the type of reviews proposed so that intelligent action may be taken toward permanent establishment and financing, the Association assume financial responsibility for the first supplement without added cost to the membership—such supplement not to exceed 100 pages of present JOURNAL size;

(3) That a special committee or editorial board be appointed as a subcommittee of the present Publications Committee, or as a separate committee with the Publications Committee represented thereon (a) to outline policies; (b) to select carefully the subjects for review and the authors, and to arrange with the latter for their preparation, keeping in mind the desirability of selecting a subject of broad interest and maximum value to entomologists generally and that the authors should be recognized by other entomologists as especially qualified in the field of review; (c) to place such limits on the length of the reviews as may be considered desirable after consideration of the subject or subjects selected and after consultation with the Business Manager of the Association to determine the limitations imposed by Association finances, and finally (d) to provide for editing and final acceptance of the material for publication;

(4) That, after the publication of the first review supplement suggested above, consideration be given to the desirability of placing the issuance of the supplement on a permanent basis and of providing for its financing by the Association through the sale of or subscription to the supplement, an increase in membership dues, or some other appropriate means.

In view of the above recommendations, the committee suggests that it is not appropriate at the present time to furnish the information, requested by the committee of the Association of Land-Grant Colleges and Universities, on subjects in greatest need of review and outstanding authorities who might be invited to prepare the reviews because of possible conflict with the work of the committee on Review Supplements, whose appointment is recommended above. It is also suggested that the committee of the Association of Land-Grant Colleges and Universities be informed of such action as may be taken at this time by this Association.

Respectfully submitted,
P. N. ANNAND, *Chairman*
F. L. CAMPBELL

REPORTS OF BRANCHES, SECTIONS AND AFFILIATED ORGANIZATIONS

Twenty-Fifth Annual Meeting, Pacific Slope Branch

The twenty-fifth annual meeting of the Pacific Slope Branch was held at the University of Washington, Seattle, Washington, June 20 to 22, 1940. The meeting was well attended and much interest was shown in the papers and discussions throughout the sessions. There was a total of 40 papers on the program, covering many phases of entomological research.

The Thursday morning joint session with the Pacific Northwest Association of Horticulturists, Entomologists, and Plant Pathologists; American Society for Horticultural Science; and American Phytopathological Society was attended by more than 100 persons, and devoted largely to a discussion of the practical application of statistical methods. On Saturday morning there was an exhibit and demonstration of spraying and dusting machinery, particularly adapted to northwest conditions, at the Western Washington Experiment Station at Puyallup, at which there was a large attendance of members of various societies.

The annual dinner was devoted to celebrating the twenty-fifth anniversary of the founding of the Pacific Slope Branch. Four charter members were present, E. O. Essig, Harry S. Smith, L. P. Rockwood and Roy E. Campbell. Professor Essig gave an address on "The Development of Entomology on the Pacific Coast," showing lantern slides of many entomologists, some of whom are now gone, but most of them still active, who participated in this development.

Officers elected for next year were A. M. Boyce, Chairman; A. W. Cressman, Vice-Chairman; Roy E. Campbell, Sec'y-Treas. It was announced that the 1941 Pacific Slope Branch meeting would be held in Pasadena, California.

Fifteenth Annual Meeting Cotton States Branch

The fifteenth annual meeting of the Cotton States Branch of the American Association of Economic Entomologists, was held in Birmingham, Alabama, on February 7, 8, and 9, 1940. The meeting was in the nature of a celebration of the fifteenth anniversary of affiliation of southern entomologists with the parent organization.

The attendance was very disappointing and may be attributed to travel rulings passed by some organizations shortly before the end of the year 1939.

There was a total increase of 83 members in the branch during the period January, 1939, to January, 1940. The total number of members for the current year is 261.

The secretary-treasurer reported receipts of $349.22 and disbursements of $142.46, with a balance of $206.76.

Officers elected for the year 1940–41 were: Z. P. Metcalf, Chairman; F. A. Fenton, Vice-Chairman; and John T. Creighton, Secretary-Treasurer. The executive committee was granted authority by the membership to select the time and place for the 1941 meetings. These meetings will be held jointly with the annual meetings of the Texas Entomological Society at Waco, Texas.

Eastern Branch

The Eastern Branch met in Atlantic City, N. J., on November 14 and 15, 1940, at The President Hotel. W. H. White presided over a program involving forty-two papers and a round table discussion that was concerned with experimental methods and the evaluation of results. About one hundred and twenty-five members and guests were present and all sessions were well attended.

The financial report showed receipts of $3,244.56 and expenditures of $1,038.84.

J. L. Horsfall was elected Chairman, and W. S. Hough, Vice-Chairman, for the coming year; H. B. Weiss was elected Secretary-Treasurer for a period of three years.

During the business session, Dr. C. C. Hamilton was presented with a gold watch and chain, the case suitably inscribed, as a token of appreciation by the Branch for his able editorship of *Entoma*. The presentation was made by Dr. T. J. Headlee.

The third Eastern Branch award for the best contribution to the science of economic entomology presented at the 1940 Atlantic City meetings of the Branch was made to Paul J. Chapman, George W. Pearce, and A. W. Avens, for their paper entitled "The Use of Petroleum Oils as Insecticides. II. Factors Affecting the Amount of Oil Deposited on Apple Bark in Dormant Spraying."

Section on Plant Quarantine and Inspection

The Section on Plant Quarantine and Inspection met in the Franklin Room of the Benjamin Franklin Hotel in Philadelphia on Monday, December 30, at 9:00 a.m. Dr. George S. Langford, Chairman, presided over the Joint Session of the Section with the American Phytopathological Society. Following the Chairman's address on the Status of the Plant Quarantine and Inspection Section of the American Association of Economic Entomologists, two phytopathological papers were presented by W. Howard Rankin on the Dutch Elm Disease and by R. H. Porter on Seed-Borne Diseases and Plant Quarantines. The latter paper was presented by Mr. Howard P. Barss in Doctor Porter's absence.

Following the presentation of these pathological papers and their subsequent consideration, the address of the Chairman developed considerable discussion as to the status of the Section on Plant Quarantine and Inspection, its relationship to the Association, and to matters which might appropriately be presented to the annual meeting with due consideration of the relationship between the Section and the Regional and National Plant Boards.

Following this discussion a motion was approved and a committee consisting of Avery S. Hoyt, Chairman, Harry B. Weiss, Frank N. Wallace, Howard P. Barss, T. L. Aamodt, D. B. Mackie, and Clay Lyle was appointed. This committee was instructed to give consideration to the status and function of the Section and to render a report of its findings.

The afternoon session was devoted to a symposium on Plant Quarantines as Barriers to Interstate Trade upon which papers by S. A. Rohwer, D. B Mackie, A. B. Buchholz, and Lee McClain, and Richard P. White were presented to show the point

of view of the Federal governments and its cooperators, the trend of State quarantines in relation to interstate trade, and the plant shippers' view of quarantines. The very excellent material contained in these papers elicited considerable interesting and constructive discussion by those present.

Following the symposium a short business meeting was held at which the following resolutions were presented by the Committee on Resolutions:

1. In view of the lack of discussion in recent years of foreign pests which have not gained entrance to this country, some of which are frequently intercepted at the various ports of entry,

BE IT RESOLVED, That in formulating future programs that a symposium on this general subject be considered.

2. BE IT RESOLVED, That the Committee on Publications give consideration to the papers submitted by the Section of Plant Quarantine and Inspection with a view of publishing them in the JOURNAL.

A. B. BUCHHOLZ
D. B. MACKIE
W. A. MCCUBBIN

The Nominations Committee recommended the election of Dr. A. B. Buchholz as Chairman and Roy G. Richmond as Secretary for the ensuing year. The Committee's recommendations were unanimously approved by the meeting.

Unusual interest was displayed in the Section meeting as evidenced by the large attendance and participation in the discussions.

ROY G. RICHMOND, *Secretary*

REPORT OF THE SECTION OF APICULTURE

The Section of Apiculture met at 8:00 p.m., December 30, in Room 206, Benjamin Franklin Hotel, Philadelphia, Pennsylvania. Frank R. Shaw, Chairman, presided except the period devoted to the Chairman's address, when E. F. Phillips occupied the chair. The meeting was well attended and much interesting discussion developed from the six papers presented. Three papers were read by title only due to the absence of the authors.

At the conclusion of the discussions, the nominating committee consisting of James I. Hambleton, E. J. Anderson, and M. H. Haydak, presented its report, which resulted in the election of the following officers for the ensuing year: J. E. Eckert, Chairman, and W. A. Price, Secretary.

W. A. PRICE, *Secretary*

REPORT OF THE SECTION OF EXTENSION

The twelfth annual meeting of the Section of Extension, with Chairman C. B. Dibble presiding, was called to order at 1:30 p.m. the afternoon of Saturday, December 28, in the Franklin room of the Benjamin Franklin Hotel. The program was conducted in the form of two panel discussions relating to extension methods and coordination of entomology with subject matter in other fields. Dr. R. W. Leiby of New York acted as leader of the first panel which was devoted almost entirely to discussion of data obtained in a recent Indiana survey conducted to determine insect control practices and sources of information. In the light of these data, several possible means of improving the effectiveness of extension work were evolved based on the direction of efforts into those channels which are the most productive of results.

The second panel, which was in charge of Mr. S. P. Lyle of the Federal Extension Service, continued to develop the general theme of more effective extension work through coordination of entomology with other subject matter in extension programs relating to (a) crops, (b) livestock, and (c) the home. Contributions from various members showed how such coordination makes possible the presentation of a well-rounded program to the farmer, rather than a great deal of uncorrelated subject matter.

The Section of Extension also sponsored a display in the exhibit room, showing various types of literature and other materials used to promote insect control programs.

Officers elected for the coming years are: Chairman, Sam C. McCampbell; Secretary, G. F. MacLeod and a program committee consisting of Stewart Lockwood, L. G. Smith, and H. J. Ryan.

G. E. LEHKER, *Secretary*

SECTION ON TEACHING

The Section on Teaching held two sessions: at 1:30 p.m. and at 7:30 p.m. on December 29 in the Betsy Ross Room of the Benjamin Franklin Hotel. C. L. Metcalf served as Chairman and Roger C. Smith as Secretary. The average attendance was about 125. Seventeen papers dealing with teaching problems, training men for research, and methods of conducting lectures, quizzes, examinations, laboratory work, field trips, and entomological clubs, were presented by experts in these matters, in a symposium entitled "Present-Day Entomological Instruction At Its Best." Many of these papers were illustrated by demonstrations and exhibits of actual teaching aids used. The talks were significantly successful in giving practical suggestions for increasing interest in entomology and improving student achievement.

Dr. Stanley B. Freeborn of the University of California was elected Chairman and Professor S. W. Bilsing of College Station, Texas, Secretary of the Section for the year 1941.

C. L. METCALF, *Chairman*

FLORIDA ENTOMOLOGICAL SOCIETY

The Florida Entomological Society was organized January 5, 1916, and the annual meeting which was held in Gainesville, December 13 and 14, 1940, commemorated the twenty-fifth anniversary of its founding. Herbert Spencer who presided chose as the subject of his presidential address, History of the Florida Entomological Society. Dr. H. T. Fernald gave a paper on the Structure of the Taenidia of Insects. Various Phases of the Mole Cricket Campaign in Florida were discussed by Mr. C. B. Wisecup, Mr. G. B. Merrill, and Mr. A. H. Madden. Dr. Homer Hixson presented a paper on Medical and Veterinary Entomology in Florida from a Teacher's Point of View. A paper by Mr. W. L. Thompson, Some Notes on the Control of Scale Insects, was read. Dr. W. V. King and Mr. G. H. Bradley gave a paper on the Distribution of Anopheline Mosquitoes. Prof. J. R. Watson spoke on the Migrations and Food of the Lubberly Locust and Dr. J. W. Wilson discussed Entomological Problems in the Everglades. Mr. L. S. Maxwell showed some Kodachrome slides of Insects and Diseases of Ornamentals and Mr. S. O. Hill illustrated his talk on Pecan Insects and Damage with colored slides. Mr. C. D. Kime spoke of the Objectives and Activities of the Farm Products Department of the Tennessee Coal, Iron and Railroad Company.

Officers for the coming year are: President, Homer Hixson; Vice President, K. E. Bragdon; Treasurer, J. W. Wilson; Secretary, A. N. Tissot; Editor of *Florida Entomo'ogist*, J. R. Watson.

Professor J. R. Watson, the first president of the Society and editor of the *Florida Entomologist* since its beginning in 1917, was honored at the Silver Anniversary Dinner, an event of Friday evening. Dr. H. Harold Hume acted as toastmaster at this enjoyable function which was attended by about sixty entomologists and guests.

NEWELL ENTOMOLOGICAL SOCIETY

The Newell Entomological Society was host to the Florida and other entomologists at the Fifth Annual Conference held in Gainesville, at the University of Florida Union Building on March 22 and 23, 1940. Many prominent entomologists from all sections of the country were present and took part in the meeting which featured the History of Entomological Instruction in the South. Honor guest at the conference banquet, which celebrated the fiftieth anniversary of the teaching of entomology in the south, was Harcourt A. Morgan, pioneer teacher of entomology. Other guests who took part in the program were: C. L. Metcalf, Z. P. Metcalf, Arthur Gibson, Herbert Osborn, Charles H. Alden, and Milledge Murphy.

The society cooperated with the College of Agriculture in its annual Fair. The exhibit of the Department of Entomology and the society was one of the most outstanding in the Fair.

This fall the society, under the leadership of President Jack Rogers, published a journal which carried reports of the activities of the group, as well as biographical sketches of the graduates of the department.

The thirty-two active members of the society have held regular bi-monthly meetings at which time many interesting speakers were heard. The society is also supported by forty-six graduate members.

The present officers are: Jack Rogers, President; N. C. Hayslip, Vice-President; Russell Peeples, Secretary; Edwin Seabrook, Treasurer; James D. McCauley, Reporter; and John T. Creighton, Faculty Adviser.

RUSSELL PEEPLES, *Secretary*

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Organized 1889; Incorporated December 29, 1913

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